# TM 11-2245

TO 31W1-2FGC29-1

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

TECHNICAL DATA

# TELEGRAPH TERMINAL AN/FGC-29

TECHNICAL DATA

*DEPARTMENT OF THE ARMY • AUGUST 1956*

## WARNING

### DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT

Be careful when working on the plate supplies; potentials as high a. 500 volts are present on the terminals and wiring associated with transformer T3. Also be careful when working on the 115- and 230-volt line connections and on the ac and dc power distribution circuits.

### EXTREMELY HIGH VOLTAGES EXIST IN THE VOLTAGE REGULATORS

Potentials as high as 720 volts are present on transformer T1 of the voltage regulators.

### DON'T TAKE CHANCES

EO 1 Nov 66 67 NP

Change in force: C 10

EMFO LIBRARY 14 OCT 66

TM 11–2245
*C 10

CHANGE
No. 10

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., *14 July 1966*

mnt 11-1-66

# TELEGRAPH TERMINAL AN/FGC–29

TM 11–2245, 3 August 1956, is changed as follows:

*Page 1,* paragraph 2. Delete paragraph changed by C 8, 7 March 1963, and substitute new paragraph 2:

## 2. Index of Publications

Refer to the latest issue of DA Pam 310–4 to determine whether there are new editions, changes, or additional publications pertaining to this equipment, Department of the Army Pamphlet No. 310–4 is an index of current technical manuals, technical bulletins, supply manuals (types 7, 8, and 9), supply bulletins, lubrication orders, and modification work orders available through supply channels. The index lists the individual parts (–10, –20, –35P, etc) and the latest changes to and revisions of each equipment publication.

Delete paragraph 2.1 added by C 8, 7 March 1963, and changed by C 9, 8 October 1963, and substitute new paragraph 2.1:

## 2.1. Forms and Records

*a. Reports of Maintenance and Unsatisfactory Equipment.* Use equipment forms and records in accordance with the instructions in TM 38–750.

*b. Report of Damaged or Improper Shipment.* Fill out and forward DD Form 6 (Report of Damaged or Improper Shipment) as prescribed in AR 700–58 (Army), NAVSANDA Publication 378 (Navy), and AFR 71–4 (Air Force).

*c. Reporting of Equipment Manual Improvements.* The direct reporting by the individual user of errors, omissions, and recommendations for improving this manual is authorized and encouraged. DA Form 2028 (Recommended Changes to DA Publications) will be used for reporting these improvement recommendations. This form will be completed using pencil, pen, or typewriter and forwarded direct to Commanding General, U.S. Army Electronics Command, ATTN: AMSEL–MR–NMP–AD, Fort Monmouth, N.J., 07703.

*Page 1,* paragraph 3*d.* (As changed by C 8, 7 Mar 63) Change last sentence to: Selection of two-channel or four-channel diversity combining can be made at Telegraph Terminal AV/FGC–29.

*Pags 6, 7, and 8.* Add the folowing note in the places listed below:

*Note.* Odd channel marking and spacing frequencies have been reversed in some Telegraph Terminals AN/FGC–29 (channel spacing frequencies are higher than channel marking frequencies).

Paragraph 7, "Output carrier frequencies" chart below heading.

Paragraph 8, "Output carrier frequencies," "Direct path," and "Translated path" charts, below heading.

Paragraph 10, "Input carrier frequencies," "Direct path," and "Translated path" charts, below heading.

Paragraph 11, "Input and output carrier frequencies" chart, below heading.

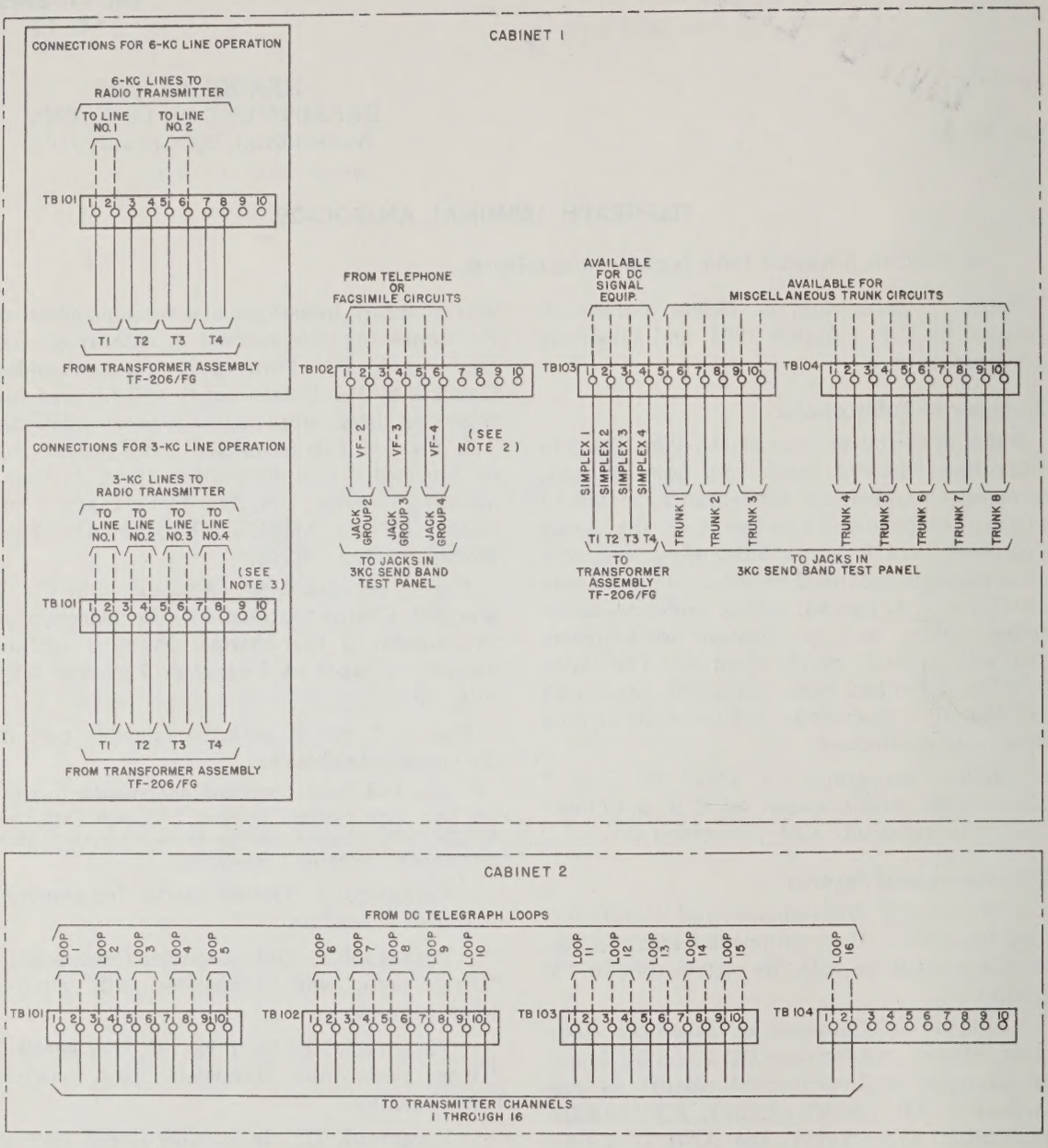
Paragraph 12, "Input quarter frequencies" chart, below heading.

* This change supersedes C 1, 2 January 1957; C 2, 8 August 1957; C 3, 26 May 1958; C 4, 5 October 1959; C 5, 10 July 1961; C 7, 30 October 1962; C 8, 7 March 1963; and C 9, 8 October 1963; and so much of SIG 7 & 8–AN/FGC–29, 27 August 1957, including C 1, 9 December 1959, and SIG 7 & 8–AN/FGR–3, 6 November 1957, including C 1, 5 April 1960, as pertains to operator's maintenance items.



EMFO LIBRARY

39/r




NOTES:

1. —— DENOTES PERMANENT WIRING.
   --- DENOTES WIRING TO BE INSTALLED.
2. CHANNEL VF-4 CANNOT BE USED WHEN AN/FGC-29 TERMINAL IS OPERATED IN FREQUENCY DIVERSITY.
3. LINE NO. 4 REQUIRED ONLY FOR SPACE DIVERSITY OPERATION.
4. LOOP NO. SAME AS TRANSMITTER CHANNEL NO.

TM2245-C10-1

*Figure 36. Transmitting terminal, external signal connections.*

*Page 48,* paragraph 52*b*(1)(*a*), chart, "Terminals" column. (As changed by C 8, 7 Mar 63). Delete from all items: (GRD).

*Page 49.* (As deleted by C 8, Mar 63). Delete paragraph 52*b*(5).

*Page 51,* figure 36. (As changed by C 8, 7 Mar 63). Delete figure 36 and substitute new figure 36.

*Page 105,* paragraph 80*b*. (As changed by C 3, 26 May 58). Make the following changes:

Line 3. Delete the word "chassis."

Line 6. Delete the last sentence and substitute: On equipments bearing Order No. 374–Phila–54 with serial numbers 75 through 113, 50 —60 switch S1 is added and appears on each tuned reactor. The controls and their functions are described below.

Chart. Add the following data to the chart:

| Control | Function |
|---|---|
| 50 —60 switch S1 | Appropriate setting of switch permits operation of loop battery supply on either 50- or 60-cps ac power supply. |

Figure 76. (As changed by C 3, 26 May 58). Make the following changes:

Label the block on the upper right-hand side of illustration: L1.

Add the following note:

NOTE. ON EQUIPMENTS BEARING ORDER NO. 374–P–54, SERIAL NUMBERS 75 THROUGH 113, L1 IS REPLACED BY TUNED REACTOR Z1. Z1 INCLUDES 50 –60 SWITCH S1 MOUNTED ON SIDE NEAREST CORDS.

*Page 106,* paragraph 83*e*. (As changed by C 3, 26 May 58). Make the following changes:

Line 3. Add the following after the parenthesis: and on each of the four loop battery supplies (2 each in cabinets 1 and 3).

Line 5. Add the following after "regulators": and loop battery supplies.

*Page 148,* paragraph 143, line 5. (As changed by C 8, 7 Mar 63). Change "(fig. 78)" to: (fig. 254).

*Page 149,* paragraph 143. (As changed by C 8, 7 Mar 63). Make the following changes:

Subparagraph *c*. Change last two sentences to: DIVERSITY switch S5 is operated manually to arrange the transmitters for two-channel or four-channel diversity operation.

Subparagraph *d*. Delete the last sentence.

*Page 150,* paragraph 146*c*. (As changed by C 8, 7 Mar 63).

Change the third sentence to: The circuit is unaltered except that the loop current from terminal 5 of terminal board TB3 (fig. 254) returns to the other side of the input loop (instead of to —130 volts dc) through contacts 1 and 3 of section 2 of switch S1, LOOP 1 (2) jacks J10 (J13) and J9 (J12) and terminal G (H) of connector J16.

Change the tenth sentence to: The loop current path from terminal 5 of terminal board TB3 is the same as explained previously for the POS position of switch S1.

*Page 151.* (As deleted by C 8, 7 Mar 63). Delete figure 78.

*Page 152.* (As changed by C 8, 7 Mar 63). Delete paragraph 146*e*.

Figure 79. (As changed by C 8, 7 Mar 63). Delete the figure (contained in separate envelope) and substitute new figure 79:

*Figure 79. Transmitter, switching circuits, simplified, schematic diagram.*
**(Located in back of change)**

*Page 153,* figure 80. Make the following changes:

Change "NOTE" to: NOTES:

Number the existing note "1" and add:

2. SOME EQUIPMENTS HAVE BEEN MODIFIED TO PROVIDE INVERTED MARKING AND SPACING OUTPUTS. THIS IS ACCOMPLISHED BY REVERSING THE DIRECTIONS OF DIODES CR1 AND CR2 (REVERSING PLATE AND CATHODE CONNECTIONS).

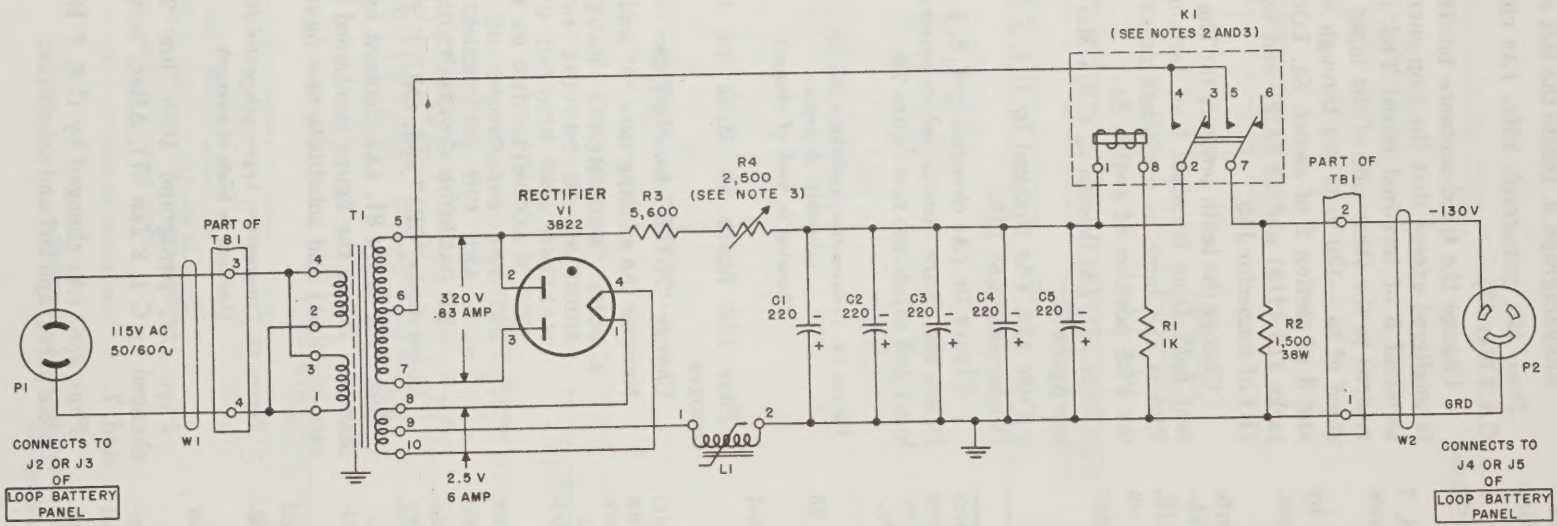
Above diode "CR1" add: (NOTE 2).

*Page 154,* figure 81. (As changed by C 8, 7 Mar 63). Delete the figure (contained in separate envelope) and substitute new figure 81:

*Figure 81. Transmitter, keyer, schematic diagram.*
**(Located in back of change)**

*Page 171,* paragraph 163*b*, line 28. (As changed by C 1, 2 Jan 57). After "terminals," add: 7.

*Page 236.* (As changed by C 8, 7 Mar 63). Delete paragraph 207 and substitute:




NOTES:

1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UF.
2. RELAY K1 IS SHOWN IN THE DE-ENERGIZED CONDITION.
3. RESISTOR R4 IS ADJUSTED TO OBTAIN A MINIMUM TIME DELAY OF 20 SECONDS IN THE OPERATION OF RELAY K1.

TM2245-C10-2

*Figure 150. Loop battery supply, schematic diagram.*

## 207. General

Switching of the combiners in the receiving terminal for either two- or four-channel diversity operation may be accomplished either manually at the terminal or electrically from a remote control station. The theory of the remote switching circuits for the combiners is discussed in paragraph 190*e*. The external connections required for remote control circuits for the receiving terminal are discussed in paragraph 52*c*(5). The theory of the remote control circuits for the receiving terminal is covered in paragraph 209.

Paragraph 208. (As deleted by C 8, 7 Mar 63). Delete paragraph 208.

*Page 237.* (As deleted by C 8, 7 Mar 63). Delete figure 141.

*Page 246,* figure 144. (As changed by C 3, 26 May 58). Change the resistance value of resistor R4 from "47K" to: 10K.

*Page 251,* paragraph 222. Make the following changes:

Paragraph heading. (As changed by C 3, 26 May 58). Change "(fig. 150)" to: (figs. 150 and 150.1).

Line 4. (As changed by C 1, 2 Jan 57). Change "+130 volts" to: —130 volts.

*Page 252.* (As changed by C 8, 7 Mar 63). Delete figure 150 and substitute new figure 150:

(As added by C 3, 26 May 58). Add figure 150.1 after figure 150:

*Page 254,* paragraph 222. Make the following changes:

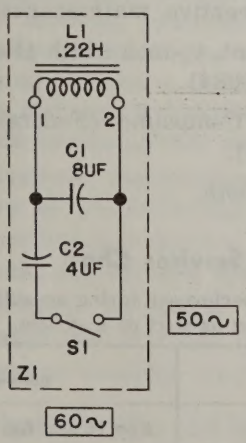



*Figure 150.1. Tuned reactor Z1, schematic diagram.*

(As changed by C 8, 7 Mar 63). Delete the third sentence from the end of paragraph and substitute: Inductor L1 acts as an anti-resonant circuit which presents a high impedance to harmonics of the power frequency.

(As added by C 3, 26 May 58). Add the following after the last sentence: On equipments bearing Order No. 374–Phila–54 with serial numbers 75 through 113 (fig. 150.1) tuned reactor Z1 replaces inductor L1 and capacitor C6. This network forms an antiresonant circuit which presents a high impedance to harmonics of the power frequency. The network consists of switch S1, inductor L1, and capacitors C1 (8 μf) and C2 (4 μf). Switch S1 selects capacitor C1 for 60-cycle operation and the combination of capacitors C1 and C2 for 50-cycle operation.

*Page 256,* paragraph 226*a*, 20 lines from bottom of subparagraph *a*.

(As added by C 2, 8 Aug 57). Add the following after "POWER fuses F1 and F2." In equipments bearing Order No. 374–Phila–54 with serial numbers 28 through 113, power is applied to transformer T3 at terminal pairs 1–2 and 3–4 from switch S2 through AC POWER fuse F2, and to transformer T4 through fuse F1.

*Page 259,* paragraph 227. (As changed by C 2, 8 Aug 57). Make the following changes:

Directly above paragraph heading, caption for figure 153. Delete the figure caption and substitute:

*TRANSMITTER METER PANEL bearing Order No. 26570–Phila–52 and Order No. 374–Phila–54 with serial numbers 1 through 27, schematic diagram.*

**(Contained in separate envelope)**

(As added by C 2, 8 Aug 57). Add the following after the figure caption for figure 153.

*Figure 153.1. TRANSMITTER METER PANEL bearing Order No. 374 with serial numbers 28 through 113.*

**(Contained in separate envelope)**

Figure 153 (contained in separate envelope). (As changed by C 2, 8 Aug 57). Delete the figure caption and substitute:

*TRANSMITTER METER PANEL bearing Order No. 26570–Phila–52 and Order No. 374–Phila–54 with serial numbers 1 through 27, schematic diagram.*

**(Contained in separate envelope)**

(As added by C 2, 8 Aug 57). Add figure 153.1 after figure 153.1.

*Figure 153.1 TRANSMITTER METER PANEL bearing Order No. 374–Phila–54 with serial numbers 28 through 113.*

**(Located in back of change)**

*Page 270.* Delete section I changed by C 9, 8 October 1963, and substitute:

## Section I. OPERATOR'S PREVENTIVE MAINTENANCE

### 231. Scope of Operator's Maintenance

The maintenance duties assigned to the operator of this equipment are listed below together with reference to the paragraph covering the specific maintenance function.

*a.* Daily preventive maintenance checks and services (para 232.3).

*b.* Cleaning (para 232.4).

### 232. Preventive Maintenance

Preventive maintenance is the systematic care, servicing, and inspection of the equipment to prevent the occurrence of trouble, to reduce downtime, and to assure that the equipment is serviceable.

*a. Systematic Care.* The procedures given in paragraph 232.3 and 232.4 cover routine systematic care and cleaning essential to proper upkeep and operation of the equipment.

*b. Preventive Maintenance Checks and Services.* The preventive maintenance checks and services chart (para 232.3) outlines functions to be performed daily. These checks and services are to maintain Army electronic equipment in a combat serviceable condition; that is, in good general (physical) condition and in good operating condition. To assist operators in maintaining combat serviceability, the chart indicates what to check, how to check, and what the normal conditions are. The *references* column lists the illustrations, paragraphs, or manuals that contain supplementary information. If the defect cannot be remedied by the operator, higher category of maintenance or repair is required. Records and reports of these checks and services must be made in accordance with TM 38–750.

### 232.1. Preventive Maintenance Checks and Services Periods

Operator's preventive maintenance checks and services on the equipment are required daily or under the conditions listed below:

(1) When the equipment is initially installed.

(2) When the equipment is reinstalled after removal for any reason.

(3) At least once each week if the equipment is maintained in a standby condition.

### 232.2. Materials

The following materials are required for operator's preventive maintenance:

*a.* Brush, paint, ½-inch width (Federal Stock No. 8020–262–9084).

*b.* Cleaning Compound (Federal Stock No. 7930–395–9542).

*c.* Lint-free cloth.

### 232.3. Operator's Daily Preventive Maintenance Checks and Services Chart

*Note.* Quarterly preventive maintenance checks and services items are performed during an authorized downtime. Do not perform the procedures below if the AN/FGC–29 is operating as part of a system.

| Sequence No. | Item to be inspected | Procedure | References |
|---|---|---|---|
| 1 | End item equipment | Inspect equipment for completeness | App II and fig. 4 through 12. |
| 2 | Cabinets (exterior only). | ***Warning:*** **Cleaning Compound (Federal Stock No. 7930–395–9542) is flammable and its fumes are toxic. Do not use near a flame; provide adequate ventilation.** | |

| Sequence No. | Item to be inspected | Procedure | References |
|---|---|---|---|
| | | Check exterior surfaces for cleanliness; remove dust and dirt with a lint-free cloth. Dampen cloth (not wet) with cleaning compound and clean as necessary. | Para 232.4 and fig. 4 through 12. |
| 3 | Knurled thumbscrews, panel mountings, hinges, latches, and meter glass. | Inspect for breakage, looseness, or other damage. | Fig. 4 through 12. |
| 4 | BLOWN FUSE INDICATORS. | Check to see that no BLOWN FUSE INDICATORS are lighted. | Fig. 1. |
| 5 | Blower motors | Check to see that the blower motors are operating. | None. |
| 6 | OUTPUT VOLTAGE meters on ac power switching panels. | Check OUTPUT VOLTAGE meters to see that they indicate the presence of ac voltage. | Fig. 73. |

## 232.4. Cleaning

Inspect the exteriors of the AN/FGC–29. The exterior surfaces should be free of dust, dirt, grease, and fungus.

*a.* Remove dust and loose dirt with a clean, soft cloth.

***Warning:*** **Cleaning Compound (Federal Stock No. 7930–395–9542) if flammable and its fumes are toxic. Provide adequate ventilation. Do not use near a flame.**

*b.* Remove grease, fungus, and ground-in dirt from the cases; use a cloth dampened (not wet) with cleaning compound.

*c.* Remove dust or dirt from plugs and jacks with a soft bristle brush.

***Caution:*** **Do not press on the meter faces (glass) when cleaning the meters; pressure on the glass will break it.**

*d.* Clean the front panels, meters, and control knobs; use a soft, clean cloth. If dirt is difficult to remove, use mild soap and water.

# Section I.1. ORGANIZATIONAL PREVENTIVE MAINTENANCE

## 232.5. Scope of Organizational Maintenance

*a.* Paragraphs 232.8 through 232.9 contain instructions covering organizational maintenance of the equipment and include instructions for performing preventive maintenance checks and services and repair function to be accomplished by the organizational repairman.

*b.* Organizational maintenance of the equipment consists of the following:

(1) Monthly preventive maintenance checks and services (para 232.8).

(2) Quarterly preventive maintenance checks and services (para 232.9).

(3) Touchup painting (para 237).

## 232.6. Tools, Materials, and Test Equipment

The following tools, materials, and test equipment are required to perform organizational maintenance and repair.

*a.* Cleaning Compound (Federal Stock No. 7930–395–9542).

*b.* Lint-free cloth.

*c.* Brush, paint, ½-inch width (Federal Stock No. 8020–262–9084).

*d.* Enamel, paint (proper type).

*e.* Multimeter TS–352/U.

*f.* Test Set, Electron Tube TV–7/U.

*g.* Tool Equipment TE–123.

## 232.7. Organizational Preventive Maintenance

*a.* Preventive maintenance is the systematic care, inspection, and servicing of the equipment to maintain it in serviceable condition, prevent breakdowns, and to assure operational capability. Preventive maintenance is the responsibility of all categories concerned with the

equipment and includes inspection, testing, and repair of the equipment parts that tests indicate would probably fail before the next scheduled periodic service. Preventive maintenance checks and services of the equipment at the organizational level are made monthly and quarterly (para 232.8 and 232.9) unless otherwise specified by the commanding office. The preventive maintenance checks and services should be scheduled concurrently with the periodic services schedule of the carrying vehicle for all vehicular installations. When the equipment is a major component of a major item (such as a van or shelter), the maintenance services and inspection procedures provided in the manual of the major item may be used.

*b.* Maintenance forms and records to be used and maintained on this equipment are specified in TM 38–750. All deficiencies or shortcomings will be recorded and those not corrected during inspection and service will be immediately reported to higher category maintenance personnel; use forms and records specified in TM 38–750.

## 232.8. Organizational Monthly Preventive Maintenance Checks and Services Chart

*Note.* Daily preventive maintenance checks and services items are performed with the equipment operating as part of a telegraph system.

| Sequence No. | Item to be inspected | Procedure | References |
|---|---|---|---|
| 1 | Exposed exterior metal surfaces. | Inspect for rust and corrosion; clean and paint as required. | Para 232.4 and 237. |
| 2 | Patch cords | Inspect patch cords for cuts, kinks, and loose or missing plugs. | Fig. 11. |
| 3 | Knobs and switches | While making operating checks (item 4 below), observe that the mechanical action of each switch and knob is smooth and free of external binding. | Fig. 4 through 12. |
| 4 | Operation | Check equipment operation | Para 82 through 122. |
| 5 | Running spares and accessory items. | Make sure that the authorized quantities of running spares and accessory items are on hand or on valid requisition. | App II. |
| 6 | Handles and latches | Inspect handles, latches, and hinges for looseness. Replace or tighten as required. | Fig. 4 through 12. |

## 232.9. Organizational Quarterly Preventive Maintenance Checks and Services Chart

*Note.* Monthly preventive maintenance checks and services items are performed during an authorized downtime. Do not perform the procedures below if the AN/FGC–29 is operating as part of a system.

| Sequence No. | Item to be inspected | Procedure | References |
|---|---|---|---|
| 1 | End item equipment | Inspect equipment for completeness | App II and fig. 4 through 12. |
| 2 | Cabinets (exterior and interior). | ***Warning:*** **Cleaning Compound (Federal Stock No. 7930–395–9542) is flammable and its fumes are toxic. Do not use near a flame; provide adequate ventilation.** | |
| | | Check surfaces for cleanliness; remove dust and dirt with a lint-free cloth. Dampen (not wet) with cleaning compound and clean as necessary. | Para 232.4 and fig. 4 through 12. |
| 3 | Knurled thumbscrews, panel mountings, hinges, latches, and meter glass. | Inspect for breakage, looseness, or other damage. | Fig. 4 through 12. |
| 4 | BLOWN FUSE INDICATORS. | Check to see that no BLOWN FUSE INDICATORS are lighted. | Fig. 1. |
| 5 | Blower motors | Check to see that the blower motors are operating. | None. |

| Sequence No. | Item to be inspected | Procedure | References |
|---|---|---|---|
| 6 | OUTPUT VOLTAGE meters on ac power switching panels. | Check OUTPUT VOLTAGE meters to see that they indicate the presence of ac voltage. | Fig. 73. |
| 7 | Exposed exterior surfaces. | Inspect for rust and corrosion; clean and paint as required. | Para 232.4 and 237. |
| 8 | Patch cords | Inspect patch cords for cuts, kinks, and loose or missing plugs. | Fig. 11. |
| 9 | Knobs and switches | While making operating checks (item 4 below), observe that the mechanical action of each switch and knob is smooth and free of external binding. | Fig. 4 through 12. |
| 10 | Operation | Check equipment operation | Para 82 through 122. |
| 11 | Running spares and accessory items. | Make sure that the authorized quantities of running spares and accessory items are on hand or on valid requisition. | App II. |
| 12 | Handles and latches | Inspect handles, latches, and hinges for looseness. Replace or tighten as required. | Fig. 4 through 12. |
| 13 | Pluckout items | Inspect clamps, and seatings of pluckout items. Check for incorrect or defective pluckout items. | Para 251 through 344. |
| 14 | Cabinets | See that all bolts, nuts, and washers are correctly installed and tight. Check for cracked, bent, or broken bracket. | Fig. 4 through 10. |
| 15 | Fuses | Check the blown-fuse indicators to make sure that no fuses are defective. Make sure that all installed fuses are of proper sizes and ratings. | Fig. 4 through 10. |
| 16 | Resistors and capacitors. | Check all resistors and capacitors for evidence of discoloration (overheating), bulging, or leakage. | Para 251 through 344. |
| 17 | Transformers and chokes. | Inspect for signs of overheating (bulges, charred insulation, leaks). | Para 251 through 344. |
| 18 | Operator's and organizational spare parts. | Check for proper stockage of operator and organizational spare parts. Check for general condition and method of storage. There should be no overstock, and shortages should be on valid requisitions. | App II. |
| 19 | Rear panel air filters | Examine the rear panel air filters to determine the need for cleaning. The dust level in some areas may necessitate a more frequent cleaning schedule. | Fig. 162 through 167. |
| 20 | Cables and cords | Check for cuts, cracked or gouged insulation, frays or kinks. | Fig. 162 through 167. |
| 21 | Terminal blocks | Inspect terminal blocks for loose or broken connections and cracked or broken insulation. | Fig. 162 through 169. |
| 22 | Jacks | Inspect jacks for snug fit and good contact | Fig. 4 through 12. |
| 23 | Lubrication | Lubricate equipment | Page 270. |
| 24 | Modifications | Check to see that all applicable MWO's have been performed. ALL URGENT MWO's must be applied immediately; all NORMAL MWO's must be scheduled. | DA Pam 310–4. |
| 25 | Installation | See that the equipment is properly installed | Para 45 through 59. |
| 26 | Preservation | Check all surfaces for evidence of fungus. Remove rust and corrosion, and spot-paint bare metal spots. | Para 237. |
| 27 | Publications | Check to see that all applicable publications are on hand and are complete (with all changes), serviceable, and current. | DA Pam 310–4. |

*Page 271,* paragraph 237. Delete paragraph 237 as changed by C 9 8 October 1963, and substitute:

### 237. Touchup Painting Instructions

Remove rust and corrosion from metal surfaces for lightly sanding them with fine sandpaper. Brush two thin coats of paint on the bare metal to protect it from further corrosion. Refer to the applicable cleaning and refinishing practices specified in TB SIG 364. Refer to paragraph 231.7 and SB 11–573 for applicable Federal stock numbers.

*Page 272,* paragraph 240*a*, chart. (As changed by C 8, 7 Mar 63). Delete the third item (Fig. No. 141).

*Page 277,* paragraph 243*c*, chart, line 2, column 3. (As changed by C 1, 2 Jan 57). Change "5Y3WGTA", to: 5Y3WGTB.

*Page 283,* paragraph 255, below heading. (As changed by C 8, 7 Mar 63). Change "(figs. 78, 130, 141, and 142)" to: (fig. 130 and 142).

*Page 365,* paragraph 299. (As changed by C 1, 2 Jan 57). Make the following changes:

Paragraph heading. Change "agc" to read: AGC.

Subparagraph *b*, chart, Test No. 13, "Normal reading (volts)" column, change "±13.60" to read: +.6.

*Page 392,* paragraph 313. (As added by C 3, 26 May 58). Add the following note after subparagraph *a*:

*Note.* On equipments bearing Order No. 374–Phila–54 with serial numbers 75 through 113, access to the voltage regulator is provided through an access door on the left of the front cover panel.

*Page 395,* paragraph 316*a*, chart. (As changed by C 3, 26 May 58), resistance (ohms) column. Make the following changes:

Item "XV1". Change "70,000" to: 33,000.

Item "XV3". Change "70,000" to: 33,000.

*Page 400,* figure 232. (As added by C 3, 26 May 58). Add the following note:

NOTE. ON EQUIPMENTS BEARING ORDER NO. 374–P–54, SERIAL NUMBERS 75 THROUGH 113, L1 IS REPLACED BY Z1. SWITCH S1 IS MOUNTED ON Z1 NEAR C3.

(As added by C 3, 26 May 58). After figure 232, add figure 232.1:

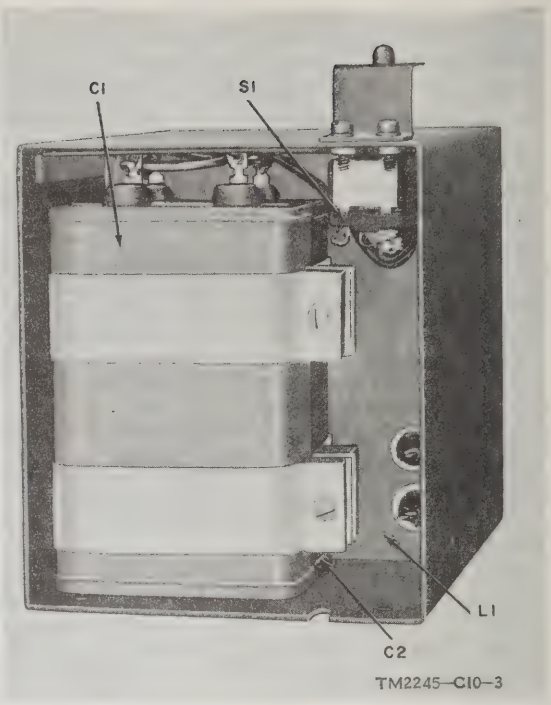



*Figure 232.1. Tuned reactor Z1 (part of loop battery supply units bearing Order No. 374–Phila–54 with serial No. 75 through 113), top view cover removed.*

*Page 401.* (As changed by C 3, 26 May 58). Make the following changes:

Figure 233. Add the following note:

NOTE. ON EQUIPMENT BEARING ORDER NO. 374–P–54, SERIAL NUMBERS 75 THROUGH 113, C6 AND L1 ARE REPLACED BY Z1. TERMINNALS DESIGNATED L1 CORRESPOND TO TERMINALS OF Z1.

Paragraph 322. Make the following changes:

Heading. Change "(fig. 232 and 233)" to: (fig. 232, 232.1, and 233).

Chart, Test No. 4 and 6. "Corrective measures" column. Change "C6" to: C5.

*Page 424,* paragraph 344. (As changed by C4, 5 Oct 59). After the last sentence, add: Adjustment procedures for polar relays K1 through K16 (Sigma Instruments Company No. 72AOZ–160–TSTCP type relays) mounted in the relay panel as described in paragraph 345.5.

(As added by C 4, 5 Oct 59). Add section XXIII.1 and figures 247.1 and 247.2 after section XXIII, chapter 5.

## Section XXIII.1. POLAR RELAY MAINTENANCE AND ADJUSTMENTS

### 345.1. General

Polar relays K1 through K16 (fig. 246) in the relay panel can be adjusted if the proper tools and test equipment (para 345.2) are available. These relays are very sensitive. Extreme care must be exercised (para 345.3) when performing preventive maintenance (para 345.4) or adjustments (para 345.5).

### 345.2. Relay Tools and Test Equipment

*a. Tools and Materials.*

(1) Jewelers screwdriver, 1/16-inch blade.
(2) Screwdriver TL–21.
(3) Short tweezers.
(4) Magnifying glass.
(5) Nonmagnetic shim, 0.009-inch by 1/8-inch strips.
(6) Paper shim, 0.004-inch by 1/8-inch strips.
(7) Hard bond paper.

*b. Test Equipment.* Test Set, Relay TS–1194/U is required to make the sensitivity adjustments on polar relays K1 through K16.

### 345.3. Precautions

*a.* When maintaining or adjusting the polar relays, avoid the following:

(1) Crossing the threads on the contact screws.
(2) Clamping the armature with the contacts or forcing the armature against a polepiece.
(3) Rough handling or dropping.
(4) Filing the contacts with a metal object.

*b.* The sensitivity adjusting screw (C, fig. 247.1) is factory-adjusted and should not be moved unless the procedures described in paragraph 345.5*b* are followed.

### 345.4. Relay Maintenance

*a.* Remove the relay cover by gripping the relay base and twisting the cover until it pulls free.

*b.* Use a magnifying glass to inspect the relay contacts (B, fig. 247.1) for buildups and pitting. If contact pitting or buildups are evident, replace the contacts (para 345.5*c*).

*c.* Inspect the damper springs (B, fig. 247.1) for unsymmetrical appearance and clearance under the damper feet. If damage is apparent, replace the contacts (para 345.5*c*).

*d.* To clean the contacts, draw a piece of clean, hard bond paper between the contact screw and armature contacts.

### 345.5. Relay Adjustment and Corrective Maintenance

The relay should be adjusted if the contacts are replaced or when troubleshooting checks indicate that the relay is the cause of excessive output distortion.

*a. Contact and Bias Adjustment.*

(1) Remove the relay cover (para 345.4*a*).
(2) Insert the relay into Test Set, Relay TS–1194/U.
(3) Unscrew both contact screws (C, fig. 247.1) until the armature rests firmly against either of the two polepieces (A, fig. 247.2).
(4) Insert one 0.004-inch paper shim, 1/8-inch-wide between the armature and one polepiece (B, fig. 247.2). Insert the shim from the rear of the relay (A, fig. 247.1).
(5) Using Test Set, Relay TS–1194/U, energize the relay with such a polarity that the armature bears on the 0.004-inch paper shim inserted as described in (4) above.
(6) Use a screwdriver to advance the diagonally opposite contact screw (C, fig. 247.2) until electrical contact is just made. Electrical contact is indicated when a lamp on the side of the TS–1194/U lights.
(7) Deenergize the relay.
(8) Remove the paper shim ((4) above) and insert it on the other side of the armature.
(9) Repeat the procedures in (5), (6), (7), and (8) above. Adjust the contact

screw diagonally opposite the paper shim.

(10) The contacts are now symmetrically arranged about the centerline through the pole gaps but are too closely spaced.

(11) Set the FUNCTION switch on the TS–1194/U to BIAS.

(12) Arrange the switch settings on the TS–1194/U to provide reversals.

(13) Adjust the bias adjusting screw (C, fig. 247.1) until the meter on the TS–1194/U indicates a bias distortion of approximately zero.

*Note.* The bias adjusting screw bears against one end of a crank. Advancing the screw pushes the crank to bias the armature against the contact connected to pin 4 (D, fig. 247.1). When the bias adjusting screw is retracted, a steel leaf spring returns the crank and maintains it against the end of the screw. Friction may make this return motion uncertain. If returning the screw has no effect, hand-twist the tension ring (A, fig. 247.1) clockwise to assist the spring. The final setting of the bias adjusting screw should be clockwise to remove the residual backlash.

(14) Retract one screw slightly, to introduce a slight bias distortion.

(15) Remove the bias distortion ((14) above) by retracting the other contact screw until the bias distortion is approximately zero.

(16) Repeat (14) and (15) above until a paper shim 0.004-inch-thick will enter both contact gaps snugly.

(17) Check the bias distortion after the contacts have been adjusted. If the bias distortion is slightly off zero, adjust the bias adjusting screw until zero bias distortion is obtained. If zero bias distortion cannot be obtained with the bias adjusting screw, perform the sensitivity adjustments (*b* below).

*b. Sensitivity Adjustment.*

(1) Back off the sensitivity adjusting screw (C, fig. 247.1) approximately 2 full turns. The relay tripping current (as indicated by the milliammeter) should change when the sensitivity adjusting screw is turned. If it does not change, replace the relay.

(2) Tap the tension ring (A, fig. 247.1) lightly with the handle of a screwdriver to remove backlash.

(3) Advance the sensitivity adjusting screw until the relay tripping current is approximately 1 milliampere (ma). A tolerance of not more than ±0.4 ma is permissible during this adjustment.

*c. Contact and Armature Replacement.*

***Caution:* Be careful not to drop the contact screws, damage may result. If a contact screw is accidently dropped, examine it carefully with a magnifying glass. If the contact screw is found to be damaged, do not use it.**

(1) Use a screwdriver to remove the contact screws.

(2) Use a jewelers screwdriver to back off the armature clamp (A, fig. 247.1) 1 turn.

(3) Remove the armature from the front end of the relay (C, fig. 247.1).

(4) Grasp the armature with tweezers and work it slowly toward the front of the relay.

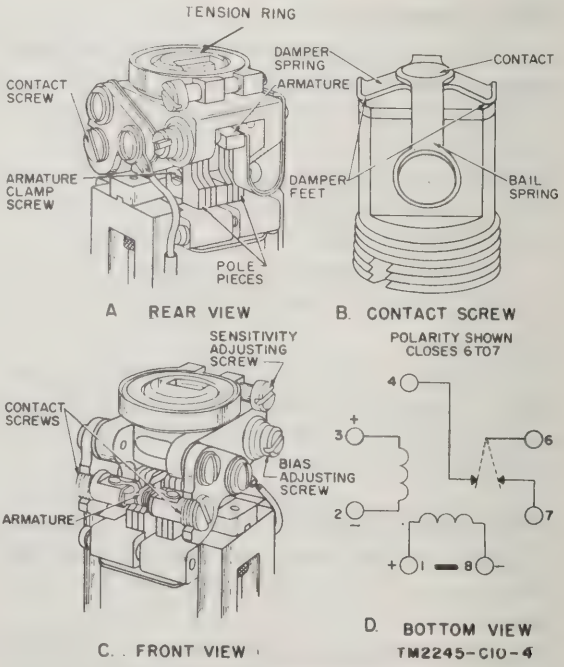



*Figure 247.1. Polar relay details*

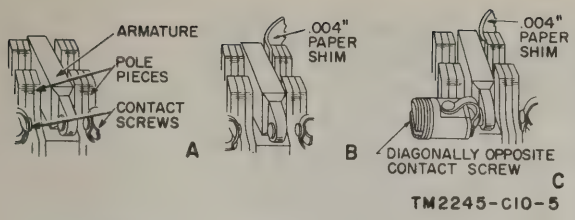



*Figure 247.2 Relay contact arrangement.*

(5) Insert a new armature from the back of the relay (A, fig. 247.1). Ease it in until the back is flush with the pole-pieces.

(6) Tighten the armature clamp screw gently until it is firmly in ulace.

(7) Insert the contact screws (B and C, fig. 247.1) and carefully screw them against the armature.

(8) Adjust the relay as described in *a* and *b* above.

*Page 427,* figure 254, sheet 1 of 2. (As changed by C 8, 7 Mar 63). Delete the figure (contained in separate envelope) and substitute new figure 254 (sheet 1 of 2).

*Figure 254. Transmitter schematic diagram (sheet 1 of 2)*

**(Located in back of change)**

*Page 428,* figure 263. (As changed by C 8, 7 Mar 63). Delete the figure (contained in separate envelope) and substitute new figure 263.

*Figure 263. Cabinet 3 wiring diagram.*

**(Located in back of change)**

Figure 268. (As changed by C 8, 7 Mar 63). Delete the figure (contained in separate envelope) and substitute new figure 268.

*Figure 268. Transmitter wiring diagram.*

**(Located in back of change)**

*Page 429.* (As changed by C 8, 7 Mar 63). Delete figure 269 and substitute new figure 269.

*Page 430,* figure 271. (As changed by C 1, 2 Jan 57). Make the following changes:

Delete note 4.

Station 1.

Terminal 1. Before "WHT–BRN" add: 16 GA.

Terminal 2. Before "BRN" add: 16 GA.

Terminal 2. Delete "P20" and associated arrows.

Station 2. Terminal 2. Change "2WHT" to: 4 WHT.

Station 3.

Terminal 5. After "WHT–BRN" on each wire, add: 16 GA.

Terminal 6. After "BRN" on each wire, add: 16 GA.

Delete "P20" and associated arrows (in two places).

Station 4. Terminal +, change "WHT 2" to: 2 WHT 2.

Station 5.

Terminal 3. Before "BRN" add: 16 GA.

Terminal 4. Before "WHT-BRN" add: 16 GA.

Delete "P20" and associated arrows.

*Page 432,* figure 276. (As changed by C 1, 2 Jan 57). Station 7, terminal 4. Change "2, 4" to: 4, 5.

*Page 441,* figure 294. (As changed by C 8, 7 Mar 63). Delete figure 294 and substitute new figure 294.

*Page 443.* (As changed by C 8, 7 Mar 63). Delete figure 299 and substitute new figure 299.

*Page 444.* (As changed by C 8, 7 Mar 63). Delete figure 300 and sustitute new figure 300.

*Separate envelope.* Make the following changes on figures contained in the separate envelope:

*Figure 34.* CABINET 6, TB 133. (As changed by C 1, 2 fan 57).

Terminal 1. Change "WHT" wire between terminal 1 of TB 133 in CABINET 6 and terminal 3 of TB 133 in CABINET 5 to read: GY.

NOTES:

1. WIRES NOT OTHERWISE SPECIFIED ARE 22 GAGE WITH NYLON JACKET.
2. BS DENOTES 22 GAGE TINNED, ANNEALED COPPER WIRING.
3. U DENOTES SHIELDED 22 GAGE WIRE WITH EXTRUDED NYLON JACKET.
4. PE DENOTES 22 GAGE WIRE WITH POLYETHYLENE INSULATION AND AND NYLON JACKET.
5. PE-U DENOTES 22 GAGE SHIELDED WIRE POLYETHYLENE INSULATION AND EXTRUDED NYLON JACKET.
6. D2 DENOTES WIRING RUN IN A SPECIFIC PATH AT TIME OF MANUFACTURE. ON REPLACEMENT OF D2 WIRING DO NOT DEVIATE FROM THIS PATH.

* KEYER Y1; CONNECTION TO TERMINAL C OF [EQUIPMENT] JACK J10.
KEYER Y2; CONNECTION TO TERMINAL C OF [EQUIPMENT] JACK J13.

7. P20 DENOTES TWISTED PAIR 20 GAGE WITH NYLON JACKET.
8. PT DENOTES LEADS PART OF APPARATUS
9. DI DENOTES WIRING CONNECTION FROM TERMINAL TO TERMINAL IN SHORTEST POSSIBLE MANNER.
10. PARTS MOUNTED ON TERMINALS THROUGH 16 ARE ON OPPOSITE SIDE OF TERMINAL BOARD FROM THOSE ON TERMINALS 17 THROUGH 32.
11. RESISTORS R9 THROUGH R13, R25 AND R26 ARE MOUNTED ON TOP SURFACE OF KEYER CHASSIS.
12. (⌒) DENOTES SHIELDED CONNECTION.
13. TNC DENOTES TERMINAL NEAREST CHASSIS.
14. SOME EQUIPMENTS HAVE BEEN MODIFIED TO PROVIDE INVERTED MARKING AND SPACING OUTPUTS BY REVERSING DIRECTIONS OF DIODES CR1 AND CR2. (PLATE AND CATHODE CONNECTIONS REVERSED).

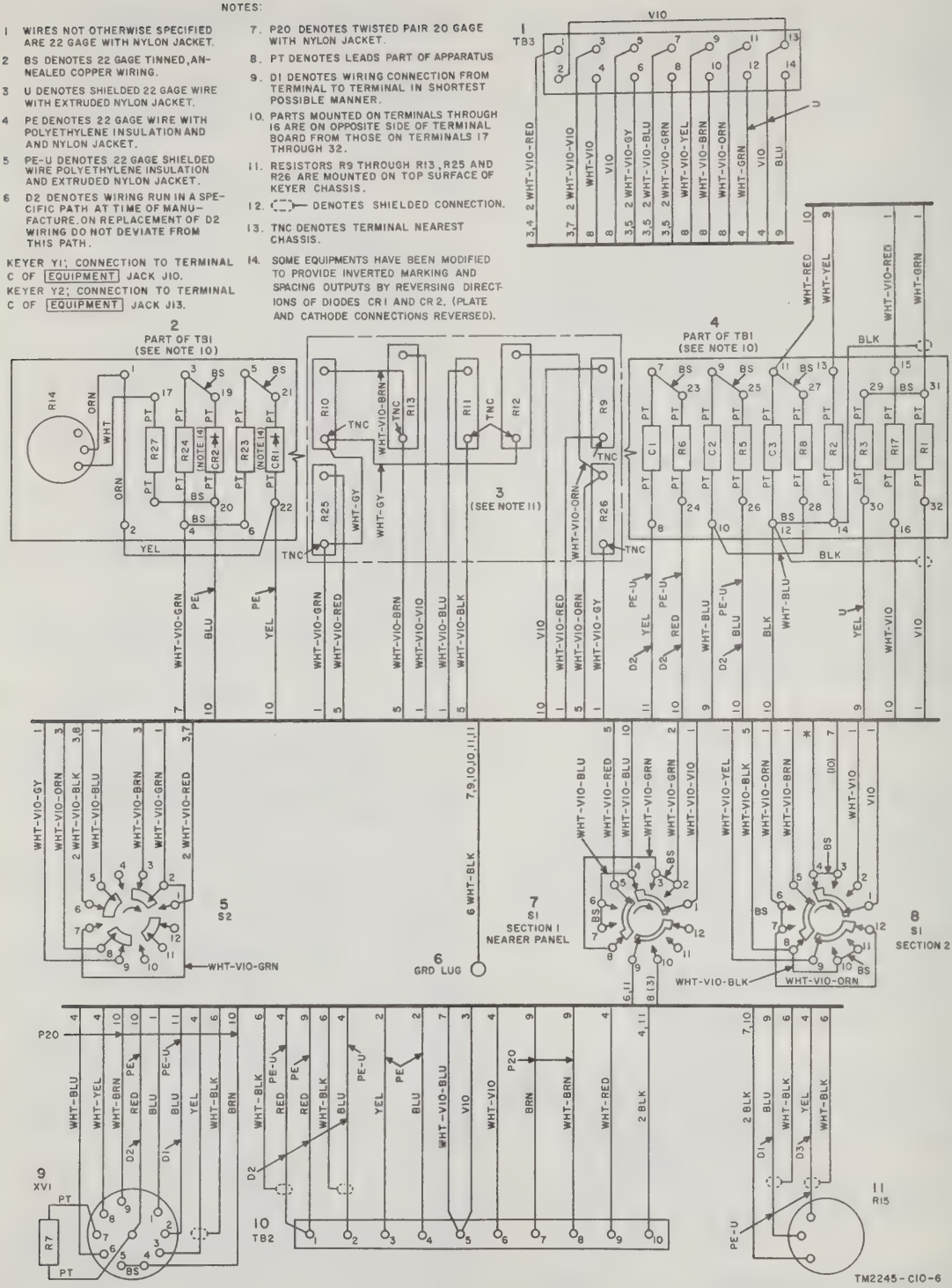
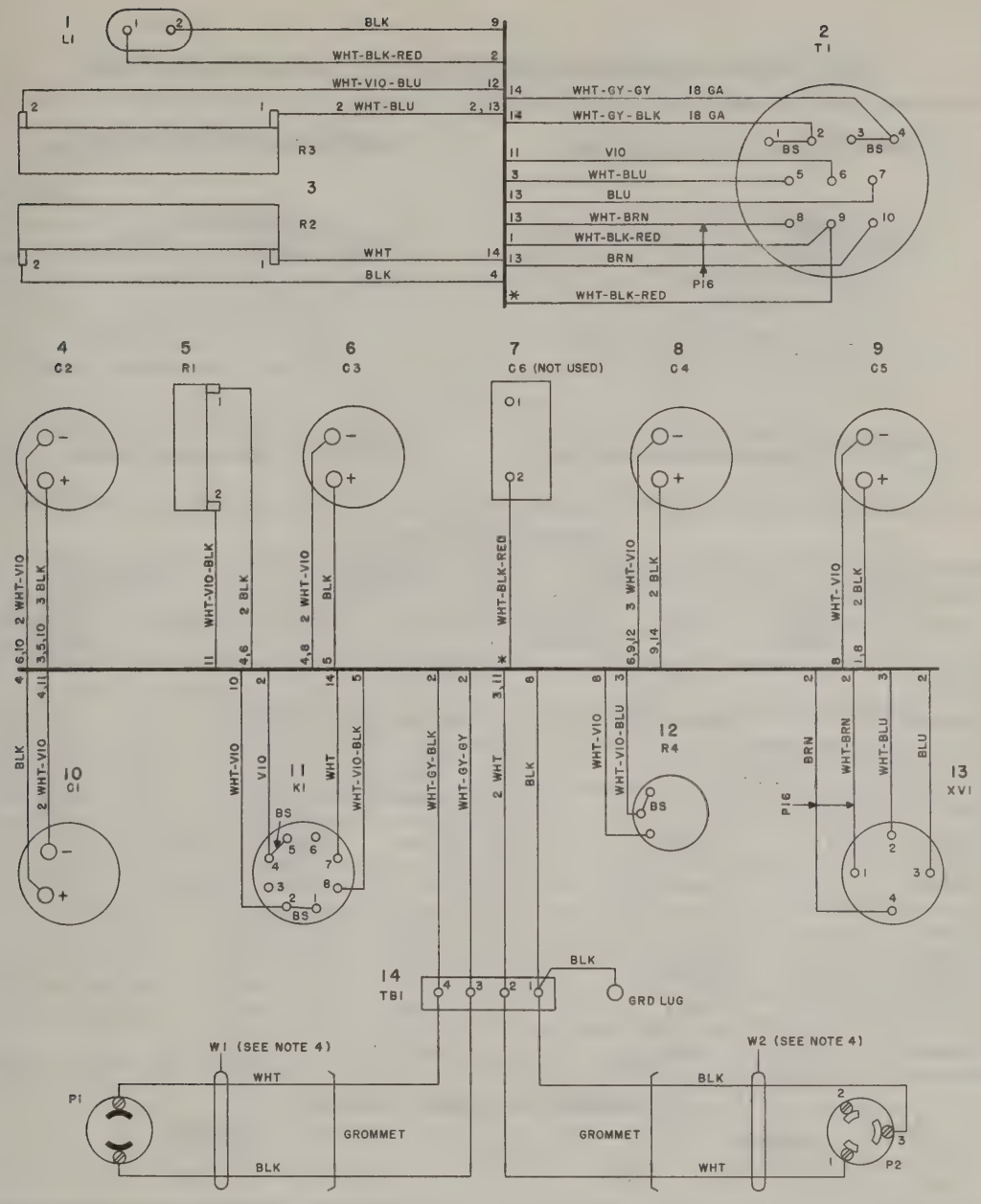



*Figure 269. Transmitter, keyer, wiring diagram.*




NOTES:

1. WIRES NOT OTHERWISE SPECIFIED ARE 22 GAGE WITH NYLON JACKET.
2. BS DENOTES 22 GAGE TINNED, ANNEALED COPPER WIRING.
3. P16 DENOTES TWISTED PAIR 16 GAGE WITH NYLON JACKET
4. CABLE ASSEMBLIES W1 AND W2 ARE MOLDED RUBBER CABLES WITH 16 GAGE CONDUCTORS.

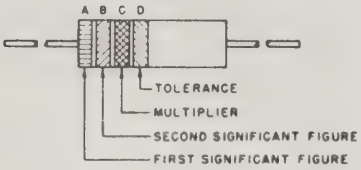
* DISCONNECTED AND TAPED TO PERFORM MWO.

TM2245-C10-7

*Figure 294. Loop battery supply, wiring diagram.*

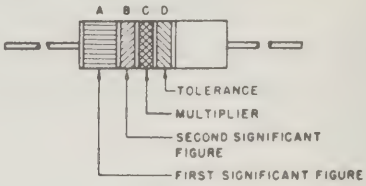
## COLOR CODE MARKING FOR MILITARY STANDARD RESISTORS

### COMPOSITION-TYPE RESISTORS




BAND A— Equal Width Band Signifies Composition-Type

### WIREWOUND-TYPE RESISTORS

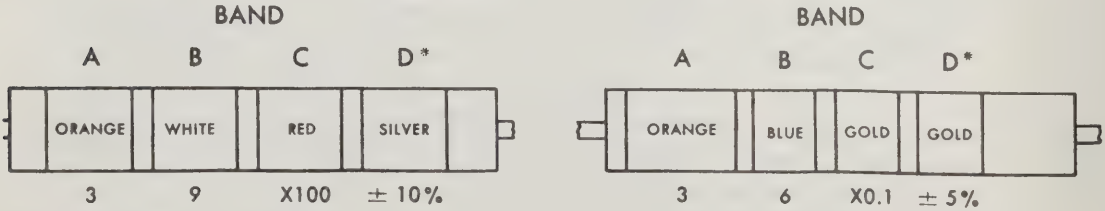



BAND A— Double Width Signifies Wire-wound Resistor

### COLOR CODE TABLE

| BAND A | | BAND B | | BAND C | | BAND D* | |
|---|---|---|---|---|---|---|---|
| COLOR | FIRST SIGNIFICANT FIGURE | COLOR | SECOND SIGNIFICANT FIGURE | COLOR | MULTIPLIER | COLOR | RESISTANCE TOLERANCE (PERCENT) |
| BLACK | 0 | BLACK | 0 | BLACK | 1 | | |
| BROWN | 1 | BROWN | 1 | BROWN | 10 | | |
| RED | 2 | RED | 2 | RED | 100 | | |
| ORANGE | 3 | ORANGE | 3 | ORANGE | 1,000 | | |
| YELLOW | 4 | YELLOW | 4 | YELLOW | 10,000 | SILVER | ± 10 |
| GREEN | 5 | GREEN | 5 | GREEN | 100,000 | GOLD | ± 5 |
| BLUE | 6 | BLUE | 6 | BLUE | 1,000,000 | | |
| PURPLE (VIOLET) | 7 | PURPLE (VIOLET) | 7 | | | | |
| GRAY | 8 | GRAY | 8 | SILVER | 0.01 | | |
| WHITE | 9 | WHITE | 9 | GOLD | 0.1 | | |

### EXAMPLES OF COLOR CODING




NOMINAL RESISTANCE 3,900 Ohms 3.6 Ohms

RESISTANCE TOLERANCE ± 10 percent ± 5 percent

STD-R2

*If Band D is omitted, the resistor tolerance is ± 20%, and the resistor is not Mil-Std.

*Figure 299. MIL-STD resistor color code markings.*

## COLOR CODE TABLES

### , CY and CB

| CAPACITANCE TOLERANCE | | | | CHARACTERISTIC[2] | | | | DC WORKING VOLTAGE | OPERATING TEMP. RANGE | VIBRATION GRADE |
|---|---|---|---|---|---|---|---|---|---|---|
| CM | CN | CY | CB | CM | CN | CY | CB | CM | CM | CM |
| | | ± 20% | ± 20% | | A | | | | −55° to +70°C | 10–55 cps |
| | | | | B | E | | B | | | |
| ± 2% | | ± 2% | ± 2% | C | | C | | | −55° to +85°C | |
| | ± 30% | | | D | | | D | 300 | | |
| | | | | E | | | | | −55° to +125°C | 10–2,000 cps |
| ± 5% | | | | F | | | | 500 | | |
| | | | | | | | | | −55° to +150°C | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | ± 5% | ± 5% | | | | | | | |
| ± 10% | ± 10% | ± 10% | ± 10% | | | | | | | |

### ose, Style CK

| ER[1] | CAPACITANCE TOLERANCE | MIL ID |
|---|---|---|
| | ± 20% | |
| | ± 10% | |
| | | |
| | | |
| | | CK |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

### TABLE III – For use with Group III, Temperature Compensating, Style CC

| COLOR | TEMPERATURE COEFFICIENT[4] | 1st SIG FIG | 2nd SIG FIG | MULTIPLIER[1] | CAPACITANCE TOLERANCE | | MIL ID |
|---|---|---|---|---|---|---|---|
| | | | | | Capacitances over 10uuf | Capacitances 10uuf or less | |
| BLACK | 0 | 0 | 0 | 1 | | ± 2.0uuf | CC |
| BROWN | −30 | 1 | 1 | 10 | ± 1% | | |
| RED | −80 | 2 | 2 | 100 | ± 2% | ± 0.25uuf | |
| ORANGE | −150 | 3 | 3 | 1,000 | | | |
| YELLOW | −220 | 4 | 4 | | | | |
| GREEN | −330 | 5 | 5 | | ± 5% | ± 0.5uuf | |
| BLUE | −470 | 6 | 6 | | | | |
| PURPLE (VIOLET) | −750 | 7 | 7 | | | | |
| GREY | | 8 | 8 | 0.01 | | | |
| WHITE | | 9 | 9 | 0.1 | ± 10% | | |
| GOLD | +100 | | | | | ± 1.0uuf | |
| SILVER | | | | | | | |

nificant (SIG) figures are multiplied to obtain the capacitance in uuf.

pplicable specifications: MIL–C–5, MIL–C–91, MIL–C–11272, and MIL–C–10950 respectively.

e-temperature limits designated in MIL–C–11015.

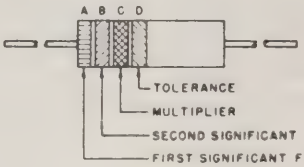
egree centigrade.

STD–C2

*Figure 300. MIL-STD capacitor color code markings.*

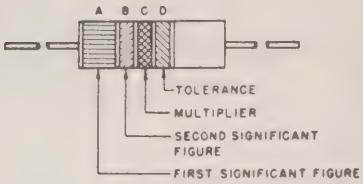
## COLOR CODE MARKING FOR MILITARY STANDARD RESISTORS

### COMPOSITION-TYPE RESISTORS




BAND A— Equal Width Band Signifies Composition-Type

### WIREWOUND-TYPE RESISTORS

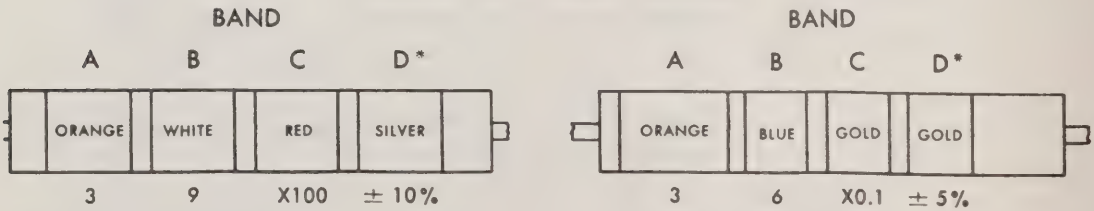



BAND A— Double Width Signifies Wire-wound Resistor

### COLOR CODE TABLE

| BAND A | | BAND B | | BAND C | | BAND D* | |
|---|---|---|---|---|---|---|---|
| COLOR | FIRST SIGNIFICANT FIGURE | COLOR | SECOND SIGNIFICANT FIGURE | COLOR | MULTIPLIER | COLOR | RESISTANCE TOLERANCE (PERCENT) |
| BLACK | 0 | BLACK | 0 | BLACK | 1 | | |
| BROWN | 1 | BROWN | 1 | BROWN | 10 | | |
| RED | 2 | RED | 2 | RED | 100 | | |
| ORANGE | 3 | ORANGE | 3 | ORANGE | 1,000 | | |
| YELLOW | 4 | YELLOW | 4 | YELLOW | 10,000 | SILVER | ± 10 |
| GREEN | 5 | GREEN | 5 | GREEN | 100,000 | GOLD | ± 5 |
| BLUE | 6 | BLUE | 6 | BLUE | 1,000,000 | | |
| PURPLE (VIOLET) | 7 | PURPLE (VIOLET) | 7 | | | | |
| GRAY | 8 | GRAY | 8 | SILVER | 0.01 | | |
| WHITE | 9 | WHITE | 9 | GOLD | 0.1 | | |

### EXAMPLES OF COLOR CODING




NOMINAL RESISTANCE 3,900 Ohms 3.6 Ohms

RESISTANCE TOLERANCE ± 10 percent ± 5 percent

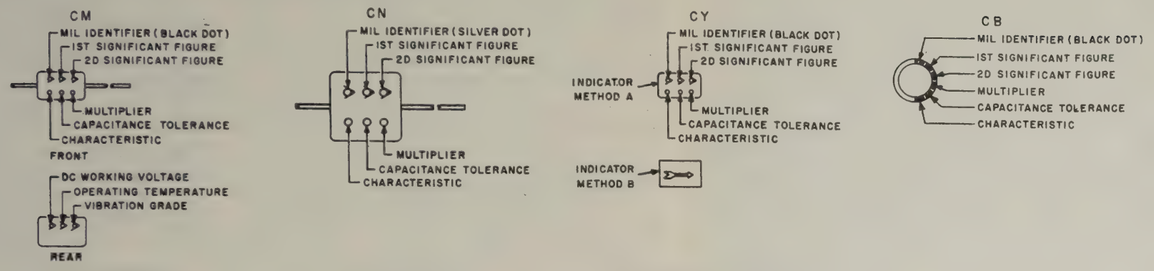
STD-R2

*If Band D is omitted, the resistor tolerance is ±20%, and the resistor is not Mil-Std.

*Figure 299. MIL-STD resistor color code markings.*

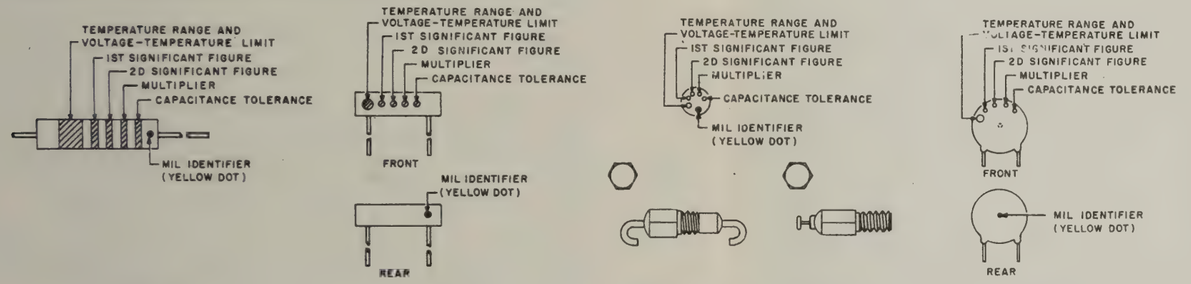
## COLOR CODE MARKING FOR MILITARY STANDARD CAPACITORS

### GROUP I Capacitors, Fixed, Various-Dielectrics, Styles CM, CN, CY, and CB



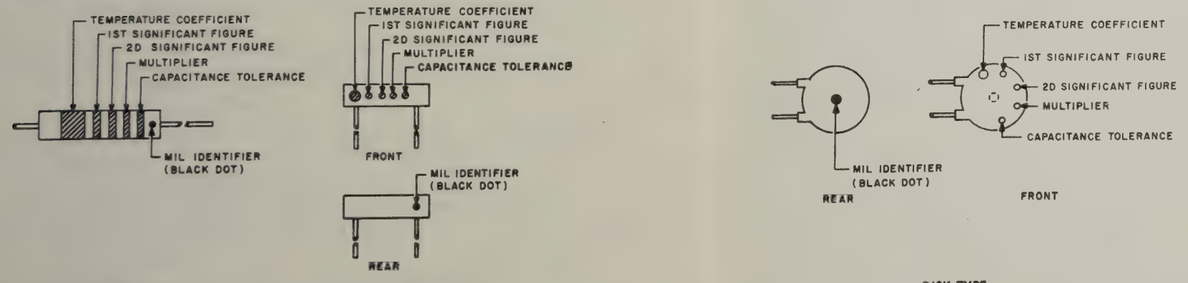

MICA-DIELECTRIC | PAPER-DIELECTRIC | GLASS-DIELECTRIC, GLASS CASE | "CA, BUTTON TYPE

### GROUP II Capacitors, Fixed Ceramic-Dielectric (General Purpose) Style CK




AXIAL LEAD | RADIAL LEAD | FEED-THROUGH | STAND-OFF | DISK-TYPE

### GROUP III Capacitors, Fixed, Ceramic-Dieletric (Temperature Compensating) Style CC




AXIAL LEAD | RADIAL LEAD | DISK-TYPE

## COLOR CODE TABLES

TABLE I – For use with Group I, Styles CM, CN, CY and CB

| COLOR | MIL ID | 1st SIG FIG | 2nd SIG FIG | MULTIPLIER[1] | CAPACITANCE TOLERANCE | | | | CHARACTERISTIC[2] | | | | DC WORKING VOLTAGE | OPERATING TEMP. RANGE | VIBRATION GRADE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | CM | CN | CY | CB | CM | CN | CY | CB | CM | CM | CM |
| BLACK | CM, CY CB | 0 | 0 | 1 | | | ± 20% | ± 20% | | A | | | | −55° to +70°C | 10–55 cps |
| BROWN | | 1 | 1 | 10 | | | | | B | E | | B | | | |
| RED | | 2 | 2 | 100 | ± 2% | | ± 2% | ± 2% | C | | C | | | −55° to +85°C | |
| ORANGE | | 3 | 3 | 1,000 | | ± 30% | | | D | | | D | 300 | | |
| YELLOW | | 4 | 4 | 10,000 | | | | | E | | | | | −55° to +125°C | 10–2,000 cps |
| GREEN | | 5 | 5 | | ± 5% | | | | F | | | | 500 | | |
| BLUE | | 6 | 6 | | | | | | | | | | | −55° to +150°C | |
| PURPLE (VIOLET) | | 7 | 7 | | | | | | | | | | | | |
| GREY | | 8 | 8 | | | | | | | | | | | | |
| WHITE | | 9 | 9 | | | | | | | | | | | | |
| GOLD | | | | 0.1 | | | ± 5% | ± 5% | | | | | | | |
| SILVER | CN | | | | ± 10% | ± 10% | ± 10% | ± 10% | | | | | | | |

TABLE II – For use with Group II, General Purpose, Style CK

| COLOR | TEMP. RANGE AND VOLTAGE – TEMP. LIMITS[3] | 1st SIG FIG | 2nd SIG FIG | MULTIPLIER[1] | CAPACITANCE TOLERANCE | MIL ID |
|---|---|---|---|---|---|---|
| BLACK | | 0 | 0 | 1 | ± 20% | |
| BROWN | AW | 1 | 1 | 10 | ± 10% | |
| RED | AX | 2 | 2 | 100 | | |
| ORANGE | BX | 3 | 3 | 1,000 | | |
| YELLOW | AV | 4 | 4 | 10,000 | | CK |
| GREEN | CZ | 5 | 5 | | | |
| BLUE | BV | 6 | 6 | | | |
| PURPLE (VIOLET) | | 7 | 7 | | | |
| GREY | | 8 | 8 | | | |
| WHITE | | 9 | 9 | | | |
| GOLD | | | | | | |
| SILVER | | | | | | |

TABLE III – For use with Group III, Temperature Compensating, Style CC

| COLOR | TEMPERATURE COEFFICIENT[4] | 1st SIG FIG | 2nd SIG FIG | MULTIPLIER[1] | CAPACITANCE TOLERANCE | | MIL ID |
|---|---|---|---|---|---|---|---|
| | | | | | Capacitances over 10uuf | Capacitances 10uuf or less | |
| BLACK | 0 | 0 | 0 | 1 | | ± 2.0uuf | CC |
| BROWN | −30 | 1 | 1 | 10 | ± 1% | | |
| RED | −80 | 2 | 2 | 100 | ± 2% | ± 0.25uuf | |
| ORANGE | −150 | 3 | 3 | 1,000 | | | |
| YELLOW | −220 | 4 | 4 | | | | |
| GREEN | −330 | 5 | 5 | | ± 5% | ± 0.5uuf | |
| BLUE | −470 | 6 | 6 | | | | |
| PURPLE (VIOLET) | −750 | 7 | 7 | | | | |
| GREY | | 8 | 8 | 0.01 | | | |
| WHITE | | 9 | 9 | 0.1 | ± 10% | | |
| GOLD | +100 | | | | | ± 1.0uuf | |
| SILVER | | | | | | | |

1. The multiplier is the number by which the two significant (SIG) figures are multiplied to obtain the capacitance in uuf.
2. Letters indicate the Characteristics designated in applicable specifications: MIL–C–5, MIL–C–91, MIL–C–11272, and MIL–C–10950 respectively.
3. Letters indicate the temperature range and voltage-temperature limits designated in MIL–C–11015.
4. Temperature coefficient in parts per million per degree centigrade.

STD–C2

*Figure 300. MIL-STD capacitor color code markings.*

Terminal 2. Change "GY" wire between terminal 2 of TB 133 in CABINET 6 and terminal 4 of TB 133 in CABINET 5 to read: WHT-GY.

*Figure 35.* (As changed by C 1, 2 Jan 57). Make the following changes:

CABINET 1, switch S1, terminal 3. Change "BLK" to: RED.

CABINET 3, switch S1, terminal 3. Change "BLK" to: RED.

CABINET 5, switch S1, terminal 3. Change "BLK" to: RED.

*Figure 262,* station 20. (As changed by C 1, 2 Jan 57). Make the following changes:

Transformer T1.

Terminal 3. Change "BRN 12 GA" to: BLK 12 GA.

Terminal 6. Change "BLK 12 GA" to: BRN 14 GA.

Fuseholder XF3.

Change "BLK" to: BRN.
Change "WHT-BLK" to: BLU.

Fuseholder XF4.

Change "BRN" to: BLK.
Change "WHT–BRN" to: BRN.

Fuseholder XF5.

Change "WHT" to: WHT–RED.
Change "WHT–VIO" to: WHT.

Switch S1.

Terminal 3. Change "BLK 12 GA" to: RED 12 GA.

Terminal 4. Change "WHT 12 GA" to: WHT–RED 12 GA.

*Figure 264,* station 31 and *figure 266,* station 31. (As changed by C 1, 2 Jan 57). Make the following changes:

Transformer T1.

Terminal 3. Change "BRN 12 GA" to: BLK 12 GA.

Terminal 6. Change "BLK 12 GA" to: BRN 14 GA.

Fuseholder XF3.

Change "BLK" to: BRN.
Change "WHT–BLK" to: BLU.

Fuseholder XF4.

Change "BRN" to: BLK.
Change "WHT–BRN" to: BRN.

Fuseholder XF5.

Change "WHT" to: WHT–RED.
Change "WHT–VIO" to: WHT.

Switch S1.

Terminal 3. Change "BLK 12 GA" to: RED 12 GA.

Terminal 4. Change "WHT 12 GA" to: WHT–RED 12 GA.

*Figure 282.* (As changed by C 1, 2 Jan 57). Make the following changes:

Station 11, jacks J1 and J2.

Add a GRN strap between the second terminal from the left side of J2. Add a strap between the middle terminal and the extreme right hand terminal of J2. Label this connection to read: BS.

Station 12, jack J4. Delete the ORN strap between the second terminal from the left side and the extreme right side of J4. Station 13, jacks J7 and J8. Add a WHT–GRN strap between the second terminal from the left side of J7 and the second terminal from the left side of J8.

Station 14, jack J10. Add a strap between the middle terminal and the extreme right hand terminal of J10. Label this connection to read: BS.

*Figure 285,* station 17. (As changed by C 1, 2 Jan 57). Make the following changes:

Delete the "WHT–BRN 6" connection to terminal 11.

Add a connection from the base line to terminal 8. Label this connection to read: WHT–BRN 6.

*Figure 295.* (As changed by C 2, 8 Aug 57). Add the following after note 8:

9. WIRING DIAGRAM BECOMES APPLICABLE TO EQUIPMENT BEARING ORDER NO. 374–PHILA–54 WITH SERIAL NO. 28 THROUGH 113, BY MAKING THE FOLLOWING CHANGES:

STATION 1.

CENTER TERMINAL. CONNECT THE CENTER TERMINAL TO THE BASE LINE. LABEL THIS CONNECTION TO READ: WHT–GY–GY 18.

OUTER TERMINAL. CHANGE "WHT–GY–GY 18 GA" to READ: WHT–GY–GY 31.

STATION 2.

CENTER TERMINAL. CONNECT THE CENTER TERMINAL TO THE BASE LINE. LABEL THIS CONNECTION TO READ: WHT–GY–BLK 31.

STATION 18.

TERMINAL 1. DELETE THE LINE AND ASSOCIATED LETTERING BETWEEN TERMINAL 1 AND THE BASE LINE.

TERMINAL 2. CHANGE "WHT–GY–GY 18 GA 1" TO READ: WHT–GY–GY 1.

TERMINAL 3. DELETE THE LINE AND ASSOCIATED LETTERING BETWEEN TERMINAL 3 AND THE BASE LINE.

STATION 31.

TERMINAL 1. CHANGE "18 WHT–GY–GY 18 GA" TO READ: 1 WHT–GY–GY.

TERMINAL 3. CHANGE "18 WHT–GY–BLK 18 GA" TO READ: 2 WHT–GY–BLK.

Delete appendix I, changed by C 9, 8 October1963, as substitute:

## APPENDIX I

## REFERENCES

| | |
|---|---|
| AR 320–5 | Dictionary of United States Army Terms. |
| AR 320–50 | Authorized Abbreviations and Brevity Codes. |
| AR 750–5 | Organization, Policies, and Responsibilities for Maintenance Operations. |
| DA Pam 310–4 | Index of Technical Manuals, Technical Bulletins, Supply Manuals (types 7, 8, and 9), Supply Bulletins, Lubrication Orders, and Modification Work Orders. |
| MWO 11–5805–251–35/1 | Modification of Relay Panel, Part of Telegraph Terminal AN/FGC–29 to Eliminate a Shock Hazard. |
| MWO 11–5805–273–35/1 | Modification of Loop Battery Supply, Part of Telegraph Terminal AN/FGC–29, to Eliminate Distortion on the Power Supply. |
| SB 11–573 | Painting and Preservation Supplies Available for Field Use For Electronics Command Equipment. |
| SB 38–100 | Preservation, Packaging, and Packing Materials, Supplies, and Equipment Used by the Army. |
| CSC 5180–91–CL–SO7 | Component List Tool Equipment TE–123. |
| SM SIG 7 & 8 AN/FGC–29 | Terminal, Telegraph AN/FGC–29. |
| TB SIG 222 | Solder and Soldering. |
| TB SIG 364 | Field Instructions for Painting and Preserving Electronics Command Equipment. |
| TM 11–2096 | Test Sets TS–140/PCM; Signal Generator SG–15/PCM and SG–15A/PCM and Decibel Meters ME–22/PCM and ME–22A/PCM. |
| TM 11–2265 | Multimeters TD–97/FGT–2 and TD–97A/FGT–2; Demultiplexers TD–98/FGR–3 and TD–98A/FGR–3; and Audio Frequency Amplifier AM–911/FG. |
| TM 11–5527 | Multimeters TS–352/U, TS–352A/U, and TS–352B/U. |
| TM 11–5805–273–20P | Organizational Maintenance Repair Parts and Special Tool Lists Terminal, Telegraph AN/FGC–29. |

| | |
|---|---|
| TM 11–5805–273–35P | Field and Depot Maintenance Repair Parts and Special Tool Lists Terminal, Telegraph AN/FGC–29. |
| TM 11–6625–218–12 | Organizational Maintenance Manual: Frequency Meter AN/TSM–16. |
| TM 11–6625–274–12 | Operator's and Organizational Maintenance Manual: Test Sets, Electron Tube TV–7/U, TV–7A/U, TV–7B/U, and TV–7D/U. |
| TM 11–6625–316–12 | Operator and Organizational Maintenance Manual: Test Sets, Electron Tube TV–2/U, TV–2A/U, TV–2B/U, and TV–2C/U. |
| TM 11–6625–320–12 | Organizational Maintenance Manual: Voltmeter, Meter ME–30A/U and Voltmeters, Electronic ME–30B/U, ME–30C/U, and ME–30E/U. |
| TM 38–750 | Army Equipment Record Procedures. |

(As added by C 7, 30 Oct 62). Add appendix III (redesignated as appendix II).

# APPENDIX II

# BASIC ISSUE ITEMS TERMINAL, TELEGRAPH AN/FGC–29

## Section I. INTRODUCTION

### 1. General

This appendix lists items supplied for initial operation and for running spares. The list includes tools, parts, and material issued as part of the major end item. The list includes all items authorized for basic operator maintenance of the equipment. End items of equipment are issued on the basis of allowances prescribed in equipment authorization tables and other documents that are a basis for requisitioning.

### 2. Columns

*a. Source, Maintenance, and Recoverability Code.* Not used.

*b. Federal Stock Number.* This column lists the 11-digit Federal stock number.

*c. Designation by Model.* Not used.

*d. Description.* Nomenclature or the standard item name and brief identifying data for each item are listed in this column. When requisitioning, enter the nomenclature and description.

*e. Unit of Issue.* The unit of issue is *each* unless otherwise indicated and is the supply term by which the individual item is counted for procurement, storage, requisitioning, allowances, and issue purposes.

*f. Expendability.* Nonexpendable items are indicated by NX. Expendable items are not annotated.

*g. Quantity Authorized.* Under "Items Comprising an Operable Equipment," the column lists the quantity of items supplied for the initial operation of the equipment. Under "Running Spare Items" the quantities listed are those issued initially with the equipment as spare parts. The quantities are authorized to be kept on hand by the operator for maintenance of the equipment.

*h. Illustrations.* Not used.

| (1) SOURCE MAINTENANCE AND RECOVERABILITY CODE | (2) FEDERAL STOCK NUMBER | (3) DESIGNATION BY MODEL | (4) DESCRIPTION | (5) UNIT OF ISSUE | (6) EXPENDABILITY | (7) QUANTITY AUTHORIZED | (8) ILLUSTRATIONS FIGURE NO | (9) ILLUSTRATIONS ITEM NO |
|---|---|---|---|---|---|---|---|---|
| | 5805-338-4450 | | TERMINAL, TELEGRAPH AN/FGC-29: freq div type; 16 channels, 425 to 2975 cyc mid-band channel freq range; 170 cyc spacing between channels; max speed 100 wpm; 115/230v ac, 50-60 cyc, single ph, 4 wire line termination; dc loops arranged for neutral oper sw selection; c/o 1 ea Terminal Telegraph AN/FGT-2 and 1 ea Terminal Telegraph; MIL spec MIL-T-11958 | | NX | | | |
| | | | ITEMS COMPRISING AN OPERABLE EQUIPMENT | | | | | |
| | Ord thru AGC | | TECHNICAL MANUAL TM 11-2245 | | | 2 | | |
| | 5805-503-0914 | | AMPLIFIER; AUDIO FREQUENCY AM-911/FG: 160 MW power output, 50v gain; 115v, 50 to 60 cyc 7 in lg x 9 in x 19 in w o/a; Sig dwg No. SC-DL-174670; (NOTE: 2 ea installed in AN/FGT-2; 2 ea installed in AN/FGR-3) (Installed in equip) | | NX | 4 | | |
| | 5995-577-8348 | | CABLE ASSEMBLY, SPECIAL PURPOSE, ELECTRICAL: 19 cond; MS3106B-22-14S connector 1 ea; MS3106B-22-14P connector other end; Sig dwg SM-D-372016 (Not installed) | | | 7 | | |
| | 5995-549-7442 | | CORD ASSEMBLY, ELECTRICAL: 2 tinsel cond; 1 ea WECo plug No. 347 on ea end; approx 6 ft lg; WECo part No. 2P1D (Not installed) | | | 2 | | |
| | 5995-549-7438 | | CORD ASSEMBLY, ELECTRICAL: 4 tinsel cond; 1 ea plug WECo No. 327 on ea end; approx 2 ft lg o/a; WECo part No. 4P18A (Not installed) | | | 2 | | |
| | 5995-549-7439 | | CORD ASSEMBLY, ELECTRICAL: 4 tinsel cond; 1 ea plug WECo No. 327 on ea end; approx 4 ft lg; WECo part No. 4P18B (Not installed) | | | 2 | | |
| | 5995-549-7440 | | CORD ASSEMBLY, ELECTRICAL: 4 tinsel cond; 1 ea WECo plug No. 327 on ea end; approx 6 ft lg; WECo part No. 4P18C (Not installed) | | | 8 | | |
| | 5995-549-7441 | | CORD ASSEMBLY, ELECTRICAL: 4 tinsel cond; 1 ea WECo plug No. 327 on ea end; approx 8 ft lg o/a; WECo part No. GB4P18E (Not installed) | | | 4 | | |
| | 5805-503-1307 | | DEMULTIPLEXER TD-98/FGT: freq div type; 2 Channel; 2460 cycles band w; 600 ohms; 115v, 50 and 60 cycles; 7 in x 8 in x 19 in o/a; Sig dwg No. SL-17459U; (NOTE: 3 ea installed in AN/FGR-3) (Installed in equip) | | NX | 3 | | |
| | 5805-831-4017 | | DUMMY CIRCUIT PANEL: 19 in lg x 6-15/16 in h x 3-15/16 in d o/a; (Installed in equip) | | | 7 | | |
| | 5965-543-1895 | | HEADSET H-110/G: 1110 ohm impedance (Not installed) | | | 2 | | |
| | 5805-823-2371 | | LOOP BATTERY SUPPLY: Electronic type rect; dic.-130 volts, 830 ma, ac-2.5v, 6 amps 115v 60 cyc single ph; 11 in lg x 8-1/2 in w x 5-3/8 in h o/a; Sig dwg No. SM-D-371496; (NOTE: 2 ea to be installed in AN/FGT-2; 2 ea to be installed in AN/FGR-3) (Not installed) | | NX | 4 | | |

| (1) SOURCE MAINTENANCE AND RECOVERABILITY CODE | (2) FEDERAL STOCK NUMBER | (3) DESIGNATION BY MODEL | (4) DESCRIPTION | (5) UNIT OF ISSUE | (6) EXPENDABILITY | (7) QUANTITY AUTHORIZED | (8) ILLUSTRATIONS FIGURE NO | (9) ILLUSTRATIONS ITEM NO |
|---|---|---|---|---|---|---|---|---|
| | | | AN/FGC-29 (continued) | | | | | |
| | 5805-503-1038 | | MULITIPLEXER TD-97/FGT-2: 2 Channels, 382 to 5908 freq range; 115v 60 cyc; 7 in lg x 19 in x 26 in o/a; Sig Corp dwg No. SC-DL-174340 (NOTE: 2 ea installed in AN/FGR-3) (Installed in equip) | | NX | 2 | | |
| | 5935-194-9524 | | PLUG, TELEPHONE: 4 cond; twin shank; 5 3/8 in lg o/a; WECo part No. 327A (Not installed) | | | 2 | | |
| | 6110-823-2370 | | REGULATOR; VOLTAGE: Electron tube type; 210 to 250v ac; lamp; 16-15/16 in lg x 11-3/4 in w x 10-1/2 in h; Sig dwg No. SM-D-371924; (NOTE: 1 ea to be installed in AN/FGT-2; 2 ea to be installed in AN/FGR-3) (Not installed) | | NX | 3 | | |
| | 5805-340-0377 | | RELAY PANEL: isolates tg loops of unusual batt polarity 115/230v ac; .6 to 1.4 ma trip cur; spdt (Not installed) | | NX | 1 | | |
| | 5805-537-7389 | | TERMINAL TELEGRAPH AN/FGT-2: freq div type; 16 channels, 425 to 2975 cyc mid-hand channel freq range; 4 wire line termination; MIL spec MIL-T-11958 (NOTE: Cabinets 1 and 2) | | NX | 1 | | |
| | 5805-534-2977 | | TERMINAL TELEGRAPH AN/FGR-3: freq div type; 2 bands 16 channels dual diversity, 425 to 2975 cyc mid-band channel freq range; 4 wire line termination; MIL spec MIL-T-11958 (NOTE: Cabinets 3, 4, 5 and 6) | | NX | 1 | | |
| | 5950-503-0630 | | TRANSFORMER ASSEMBLY TF-206/FG: (Not installed) | | | 1 | | |
| | | | RUNNING SPARE ITEMS | | | | | |
| | | | TERMINAL, TELEGRAPH AN/FGC-29 | | | | | |
| | 6995-577-8348 | | CABLE ASSEMBLY, SPECIAL PURPOSE ELECTRICAL: 19 cond; MS3106B-22-14S, connector 1 ea; MS3106B-22-14P connector other end; Sig dwg SM-D-372016 | | | 1 | | |
| | 5955-542-7194 | | CRYSTAL UNIT, QUARTZ: 19.36 kc; MIL type No. CR-50/U | | | 1 | | |
| | 5955-667-0209 | | CRYSTAL UNIT, QUARTZ: 25.16 kc; MIL type CR-50/U | | | 1 | | |
| | 5960-188-8570 | | ELECTRON TUBE: MIL type No. 2AS15 | | | 1 | | |
| | 5960-108-0240 | | ELECTRON TUBE: MIL type No. 3B22 | | | 2 | | |
| | 5960-262-0218 | | ELECTRON TUBE: MIL type No. 5Y3WGTA | | | 1 | | |
| | 5960-262-0152 | | ELECTRON TUBE: MIL type No. 6AU6WA | | | 2 | | |
| | 5960-615-0243 | | ELECTRON TUBE: MIL type No. 6CL6 | | | 6 | | |
| | 5960-272-9182 | | ELECTRON TUBE: MIL type No. 6X4WA | | | 6 | | |
| | 5960-114-4868 | | ELECTRON TUBE: MIL type No. 807 | | | 1 | | |
| | 5960-262-0185 | | ELECTRON TUBE: MIL type No. 5726 | | | 6 | | |

| (1) SOURCE MAINTENANCE AND RECOVERABILITY CODE | (2) FEDERAL STOCK NUMBER | (3) DESIGNATION BY MODEL | (4) DESCRIPTION | (5) UNIT OF ISSUE | (6) EXPENDABILITY | (7) QUANTITY AUTHORIZED | (8) ILLUSTRATIONS FIGURE NO. | (9) ILLUSTRATIONS ITEM NO |
|---|---|---|---|---|---|---|---|---|
| | | | AN/FGC-29 (continued) | | | | | |
| | 5960-284-9285 | | ELECTRON TUBE: MIL type No. 5727/2D21W | | | 6 | | |
| | 5960-193-5145 | | ELECTRON TUBE: MIL type No. 5751 | | | 12 | | |
| | 5960-228-5358 | | ELECTRON TUBE: MIL type No. 5814 | | | 6 | | |
| | 5960-669-6861 | | ELECTRON TUBE: MIL type No. 6005/6AQ5 | | | 6 | | |
| | 5920-229-1312 | | FUSE CARTRIDGE: 1/16 amp; MIL std type No. F02GR062B; MIL std part No. MS90078-18 | | | 10 | | |
| | 5920-356-2188 | | FUSE CARTRIDGE: 1/8 amp; MIL std type No. F02GR125A, MIL std part No. MS90078-4 | | | 5 | | |
| | 5920-281-0205 | | FUSE, CARTRIDGE: 1/8 amp; MIL std type No. F02GR125B, MIL std part No. MS90078-19 | | | 5 | | |
| | 5920-504-8634 | | FUSE, CARTRIDGE: 1/4 amp; MIL std type F02GR250B, MIL std part No. MS90078-20 | | | 10 | | |
| | 5920-518-1790 | | FUSE, CARTRIDGE: 3/8 amp; MIL std type F02GR375A | | | 15 | | |
| | 5920-227-9137 | | FUSE, CARTRIDGE: .375 amp; MIL std type No. F02GR375B, MIL std part No. MS90078-21 | | | 10 | | |
| | 5920-356-2193 | | FUSE, CARTRIDGE: 1/2 amp; MIL std type No. F02GR500A, MIL std part No. MS90078-7 | | | 20 | | |
| | 5920-199-9498 | | FUSE, CARTRIDGE: 500 amp; MIL std type No. F02GR500B, MIL std part No. MS90078-22 | | | 20 | | |
| | 5920-549-0032 | | FUSE, CARTRIDGE: 5 amp; MIL std type F09G5R00A | | | 5 | | |
| | 5920-519-8119 | | FUSE, CARTRIDGE: 20 amp; MIL std type F11D20R0A | | | 5 | | |
| | 5920-280-4465 | | FUSE, CARTRIDGE: 1 amp; MIL std type F02G1R00A; MIL std part No. MS90078-9 | | | 10 | | |
| | 5920-284-9220 | | FUSE, CARTRIDGE: 1 amp; MIL std type F02G1R00B | | | 10 | | |
| | 5920-131-9821 | | FUSE, CARTRIDGE: 3 amp; MIL std type No. F02D3R00B, MIL std part No. MS90078-27 | | | 10 | | |
| | 5920-263-0626 | | FUSE, CARTRIDGE: 3 amp; MIL std type No. F09G3R00A, MIL std part No. MS90085-19 | | | 10 | | |
| | | | FUSE, CARTRIDGE: 5 amp; MIL std type No. F09G5R00A, MIL std part No. MS90085-24 ††LOWc30-64 | | | 5 | | |

| (1) SOURCE MAINTENANCE AND RECOVERABILITY CODE | (2) FEDERAL STOCK NUMBER | (3) DESIGNATION BY MODEL | (4) DESCRIPTION | (5) UNIT OF ISSUE | (6) EXPENDABILITY | (7) QUANTITY AUTHORIZED | (8) ILLUSTRATIONS FIGURE NO | (9) ILLUSTRATIONS ITEM NO |
|---|---|---|---|---|---|---|---|---|
| | | | AN/FGC-29 (continued) | | | | | |
| | 5920-280-5066 | | FUSE, CARTRIDGE: 5 amp, 125v; time delay; 1 1/4 in lg x 1/4 in dia; Littlefuse part No. 313005 | | | 8 | | |
| | 5920-228-7874 | | FUSE, CARTRIDGE: 10 amp; MIL std type No. F11G10R0A, MIL std part No. MS90086-5 | | | 5 | | |
| | 5920-295-9600 | | FUSE, CARTRIDGE: .10 amp; 125v; 1 1/4 in lg x 1/4 in dia; Littlefuse part No. 313.100 | | | 15 | | |
| | | | FUSE, CARTRIDGE: 20 amp; MIL std type No. F11D20R0A, MIL std part No. MS90086-7 ††LOWc30-129 | | | 5 | | |
| | 6240-223-9100 | | LAMP, GLOW: 1/25w; T-3-1/4 bulb 1 3/16 in h o/a; GE part No. NE-51 | | | 10 | | |
| | 6240-057-2887 | | LAMP, INCANDESCENT: 6.3v; T-3-1/4 bulb 1-3/16 in h o/a; GE part No. 44 | | | 5 | | |
| | | | RECTIFIER, METALLIC: selenium; 260v rms; 2 5/8 in lg x 5/8 in dia o/a; Bradley part No. SE6LA10H917 ††LOWc30-86 | | | 1 | | |
| | 6130-351-6904 | | RECTIFIER, METALLIC: selenium; 700v ac; 2 5/8 in lg x 5/8 in dia o/a; Bradley part No. SE6M50H | | | 1 | | |
| | 5945-615-1457 | | RELAY, ARMATURE: spdt; .060 amp max ind rating; 3-1/4 in lg x 1 5/16 in max dia; octal socket; Sigma part No. 72A0Z-160TS-TC | | NX | 3 | | |
| | 6130-836-6506 | | RECTIFIER METALLIC: selenium; 260v rms; 2-5/8 in lg x 5/8 in dia o/a; Bradley part No. SE6LA10H917 | | | 1 | | |
| | 5960-262-0332 | | SEMICONDUCTOR DEVICE, SET: MIL type No. 1N71 | | | 5 | | |
| | 5960-646-4566 | | SEMICONDUCTOR DEVICE, DIODE: MIL type No. 1N435 | | | 6 | | |

(At added by C 5, 10 July 61). Add appendixII (redesignated as appendix III).

# APPENDIX III

# MAINTENANCE ALLOCATION

## 1. General

*a.* The maintenance allocation chart assigns maintenance functions and repair operations to be performed by the lowest appropriate maintenance category.

*b.* Columns in the maintenance allocation chart are as follows:

(1) *Part or component.* This column shows only the nomenclature or standard item name. Additional descriptive data are included only where clarification is necessary to identify the part. Components and parts comprising a major end item are listed alphabetically. Assemblies and subassemblies are in alphabetical sequence with their components listed alphabetically immediately below the assembly listing.

(2) *Maintenance function.* This column indicates the various maintenance functions allocated to the category capable of performing the operations.

(*a*) *Service.* To clean, to preserve, and to replenish fuel and lubricants.

(*b*) *Adjust.* To regulate periodically to prevent malfunction.

(*c*) *Inspect.* To verify serviceability and to detect incipient electrical or mechanical failure by scrutiny.

(*d*) *Test.* To verify serviceability and to detect incipient electrical or mechanical failure by use of special equipment such as gages, meters, etc.

(*e*) *Replace.* To substitute serviceable assemblies, subassemblies, and parts for unserviceable components.

(*f*) *Repair.* To restore an item to serviceable condition through correction of a specific failure or unserviceable condition. This function includes but is not limited to, inspecting, cleaning, preserving, adjusting, replacing, welding, riveting, and straightening.

(*g*) *Align.* To adjust two or more components of an electrical system so that their functions are properly synchronized.

(*h*) *Calibrate.* To determine, check, or rectify the graduation of an instrument, weapon, or weapons system, or components of a weapons system.

(*i*) *Rebuild.* To restore an item to a standard as near as possible to original or new condition in appearance, performance, and life expectancy. This is accomplished through the maintenance technique of complete disassembly of the item, inspection of all parts or components, repair or replacement of worn or unserviceable elements using original manufacturing tolerances and/or specifications and subsequent reassembly of the item.

(*j*) *Overhaul.* To restore an item to completely serviceable condition as prescribed by serviceability standards developed and published by heads of commodity commands. This is accomplished through employment of the technique of "Inspect and Repair Only as Necessary" (IROAN). Maximum utilization of diagnostic and test equipment is combined with minimum disassembly of the item during the overhaul process.

(3) *1st, 2d, 3d, 4th, 5th echelon.* The symbol X indicates the category responsible for performing that particular maintenance operation, but does not necessarily indicate that repair parts

will be stocked at that level. Categories of maintenance higher than those marked by X are authorized to perform the indicated operation.

(4) *Tools required.* This column indicates codes assigned to each individual tool equipment, test equipment, and maintenance equipment referenced. The grouping of codes in this column of the maintenance allocation chart indicates the tool, test, and maintenance equipment required to perform the maintenance function.

(5) *Remarks.* Entries in this column will be utilized when necessary to clarify any of the data cited in the preceding columns.

*c.* Columns in the allocation of tools for maintenance functions are as follows:

(1) *Tools required for maintenance functions.* This column lists tools, test, and maintenance equipment required to perform the maintenance functions.

(2) *1st, 2d, 3d, 4th, 5th echelon.* The dagger (†) symbol indicates the categories allocated the facility.

(3) *Tool code.* This column lists the tool code assigned.

## 2. Mounting Hardware

The basic entries of the maintenance allocation chart do not include mounting hardware such as screws, nuts, bolts, washers, brackets, clamps, etc.

## 3. Maintenance by Using Organizations

When this equipment is used by signal services organizations organic to theater headquarters or communication zones to provide theater communications, those maintenance functions allocated up to and including general support are authorized to the organization operating this equipment.

# MAINTENANCE ALLOCATION CHART

| (1) PART OR COMPONENT | (2) MAINTENANCE FUNCTION | (3) 1ST ECH | (4) 2ND ECH | (5) 3RD ECH. | (6) 4TH ECH. | (7) 5TH ECH. | (8) TOOLS REQUIRED | REMARKS |
|---|---|---|---|---|---|---|---|---|
| TERMINAL, TELEGRAPH AN/FGC-29 | | | | | | | | |
| | service | X | | | | | | Clean exterior |
| | adjust | X | | | | | | Adjust operative controls |
| | adjust | | | X | | | 4,5,6,7 | All adjustments |
| | inspect | X | | | | | | Check exterior servicability elec or mech failure |
| | | | X | | | | | Check interior elec or mech failure |
| | test | | X | | | | 1,2,7 | Test tubes, make voltage and resistance tests |
| | test | | | X | | | 4,5,6,7 | Voltage, gain, frequency |
| | test | | | | X | | 1,2,4,5,6,7 | All testing |
| | repair | | X | | | | 7 | |
| | align | | | X | | | 4,5,6,7 | Line up rec groups, combiners, delay amplifiers, and trans groups |
| | calibrate | | | | X | | 7 | Built in metering and test networks circuits |
| | rebuild | | | | | X | 7 | |
| CABLE ASSEMBLY SPECIAL PURPOSE ELECTRICAL | | | | | | | | (Inter connecting cables) |
| | replace | | X | | | | 7 | |
| | repair | | | X | | | 7 | |
| CORD ASSEMBLY, ELECTRICAL | replace | | X | | | | 7 | Replace as assembly |
| | repair | | | | X | | 7 | Repair as tinsel with rt |
| HEAD SET H-110/G | replace | | X | | | | 7 | |
| RELAY PANEL | repair | | | X | | | 7 | |
| TERMINAL TELEGRAPH AN/FGT-2 | repair | | | X | | | 7 | |
| CABINET NO. 1 | repair | | | X | | | 7 | |
| CABLE ASSEMBLY ELECTRICAL | replace | | X | | | | | |
| | repair | | | X | | | 7 | |
| FILLER PANEL | | | | | | | | |
| AMPLIFIER, AUDIO FREQUENCY AM- 911/FG | | | | | | | | See MAC |
| TRANSMITTER METER PANEL | repair | | | X | | | 7 | |
| 3 KC SEND BAND TEST PANEL | repair | | | X | | | 7 | |
| MULTIPLEXER TD-97/FGT-2 | | | | | | | | See MAC |
| STORAGE DRAWER | repair | | | X | | | 7 | |
| LOOP BATTERY PANEL | repair | | | X | | | 7 | |
| COVER PANEL NO. 2 | repair | | | X | | | 7 | |
| LOOP BATTERY SUPPLY | repair | | | X | | | 7 | |
| CABLE ASSEMBLY | replace | | X | | | | 7 | |
| | repair | | | X | | | 7 | |

| (1) PART OR COMPONENT | (2) MAINTENANCE FUNCTION | (3) 1ST ECH | (4) 2ND ECH | (5) 3RD ECH | (6) 4TH ECH | (7) 5TH ECH | (8) TOOLS REQUIRED | (9) REMARKS |
|---|---|---|---|---|---|---|---|---|
| AN/FGC-29 (continued) | | | | | | | | |
| TRANSFORMER ASSEMBLY TF-206/FG | replace | | | X | | | 7 | |
| | repair | | | X | | | 7 | |
| EXHAUSTER ASSEMBLY (FAN CENTRIFUCAL) | repair | | | X | | | 7 | |
| POWER PANEL | repair | | | X | | | 7 | |
| MAIN POWER UNIT | repair | | | X | | | 7 | |
| CABINET NO. 2 | repair | | | X | | | 7 | |
| CABLE ASSEMBLY | replace | | X | | | | 7 | |
| | repair | | | X | | | 7 | |
| AC POWER SWITCHING PANEL | repair | | | X | | | 7 | |
| FILLER PANEL NO. 1 | | | | | | | | |
| LEVEL CONTROL - PLATE SUPPLY | repair | | | X | | | 7 | |
| LINE AMPLIFIER | repair | | | X | | | 7 | |
| PLATE SUPPLY | repair | | | X | | | 7 | |
| SUBGROUP MODULATOR | repair | | | X | | | 7 | |
| CARRIER SUPPLY | repair | | | X | | | 7 | |
| CONVERTER | repair | | | X | | | 7 | |
| MODULATOR | repair | | | X | | | 7 | |
| OUTPUT COUPLER | repair | | | X | | | 7 | |
| PLATE SUPPLY | | | | | | | | Previously broken in Level Control and Plate Supply part of AN/FGT-2 |
| TRANSMITTER CHANNELS 1 thru 16 | service | | | | | | 7 | This group indicates maintenance designations for all transmitter channels appearing in Cabinet NO. 2 (AN/FGT-2) |
| BIAS SUPPLY | repair | | | X | | | 7 | |
| KEYER | repair | | | X | | | 7 | |
| OSCILLATOR TUNER 1/16, 2/15, 3/14, 4/13, 5/12, 6/11, 7/10, 8/9 | repair | | | X | | | 7 | |
| COVER PANEL NO. 3 | repair | | | X | | | 7 | |
| VOLTAGE REGULATOR | repair | | | X | | | 7 | |
| POWER PANEL | | | | | | | | See breakdown Cabinet No. 1 part of AN/FGT-2 |
| EXHAUSTER ASSEMBLY (FAN CENTRIFUGAL) | | | | | | | | See breakdown Cabinet No. 1 part of AN/FGT-2 |
| TERMINAL TELEGRAPH AN/FGR-3 | repair | | | X | | | 7 | |
| CABINET No. 3 | service | | | X | | | 7 | |
| CABLE ASSEMBLY ELECTRICAL | replace | | X | | | | 7 | |
| | repair | | | X | | | 7 | |
| FILLER PANEL No. 3 | | | | | | | | |
| AMPLIFIER, AUDIO FREQUENCY AM-911/FG | | | | | | | | See MAC |
| DIVERSITY ALIGNMENT PANEL | repair | | | X | | | 7 | |

| (1) PART OR COMPONENT | (2) MAINTENANCE FUNCTION | (3) 1ST ECH | (4) 2ND ECH | (5) 3RD ECH | (6) 4TH ECH. | (7) 5TH ECH. | (8) TOOLS REQUIRED | (9) REMARKS |
|---|---|---|---|---|---|---|---|---|
| AN/FGC-29 (continued) | | | | | | | | |
| 3 KC RECEIVE BAND TEST PANEL | repair | | | X | | | | |
| DEMULTIPLEXER TD-98/FGR-3 | | | | | | | | See MAC |
| DUMMY CIRCUIT PANEL | replace | | X | | | | 7 | |
| | repair | | | X | | | 7 | |
| LOOP BATTERY PANEL | | | | | | | | See Loop Battery Panel Cabinet No. 1 part of AN/FGT-2 for breakdown |
| COVER PANEL No. 2 | | | | | | | | See Cover Panel No.2 Cabinet No. 1, part of AN/FGT-2 for breakdown |
| LOOP BATTERY SUPPLY | | | | | | | | See Loop Battery Supply, Cabinet No. 1 part of AN/FGT-2 for breakdown |
| TRANSFORMER ASSEMBLY TF-206/FG | | | | | | | | See Transformer Assembly TS-206/FG. Cabinet No. 1 part of AN/FGT-2, for breakdown |
| EXHAUSTER ASSEMBLY (FAN CENTRIFUGAL) | | | | | | | | See Exhauster Assy (Fan Centrifugal, Cabinet No. 1, part of AN/FGT-2 for breakdown |
| POWER PANEL | | | | | | | | See Power Panel, Cabinet No. 1 part of AN/FGT-2 for breakdown |
| MAIN POWER UNIT | | | | | | | | See Main Power Unit Cabinet No. 1, part of AN/FGT-2 for breakdown |
| CABINET No. 4 | repair | | | X | | | 7 | |
| CABLE ASSEMBLY ELECTRICAL | replace | | X | | | | 7 | |
| | repair | | | X | | | 7 | |
| AC POWER SWITHCHING PANEL | | | | | | | | See AC Power Switching Panel, Cabinet No. 2 part of AN/FGT-2 for breakdown |
| RECIEVER CHANNELS 1 thru 16 | | | | | | | | This group includes maintenance designations for all Receiver Channels |
| | repair | | | X | | | 7 | |
| PLATE SUPPLY | | | | | | | | See Plate Supply, Level Control and Plate Supply Cabinet No. 2, part of AN/FGT-2 for breakdown |
| DELAY AMPLIFIERS 1/16, 2/15, 3/14, 4/13 5/12, 6/11, 7/10, 8/9 | repair | | | X | | | 7 | |
| DELAY TUNERS 1/16, 2/15, 3/14, 4,13, 5/12, 6/11, 7/12, 8/9 | replace | | | X | | | 7 | |
| | repair | | | X | | | 7 | |

| (1) PART OR COMPONENT | (2) MAINTENANCE FUNCTION | (3) 1ST ECH | (4) 2ND ECH | (5) 3RD ECH | (6) 4TH ECH | (7) 5TH ECH | (8) TOOLS REQUIRED | (9) REMARKS |
|---|---|---|---|---|---|---|---|---|
| AN/FGC-29 (continued) | | | | | | | | |
| AGC AMPLIFIER | repair | | | X | | | 7 | |
| COMBINERS 1 thru 16 | | | | | | | | This group includes maintenance designations for all Combination Channels |
| ADDER | repair | | | X | | | 7 | |
| TRANSFORMER REACTOR ASSEMBLY | repair | | | X | | | 7 | |
| RECEIVER CHANNNEL No. 2 | | | | | | | | See Reciever Channels 1 thru 16, Cabinet No. 4 for breakdown |
| RECEIVER CHANNEL No. 3 | | | | | | | | See Receiver Channels 1 thru 16, Cabinet No. 4 for breakdown |
| COMBINER CHANNELS Nos. 3 and 4 | | | | | | | | See Combiner Channels 1 thru 16, Cabinet No. 4 for breakdown |
| RECEIVER CHANNEL No. 4 | | | | | | | | See Receiver Channels 1 thru 16, Cabinet No. 4 for breakdown |
| RECEIVER CHANNEL No. 5 | | | | | | | | See Receiver Channels 1 thru 16, Cabinet No. 4 for breakdown |
| COMBINER CHANNEL Nos. 5 and 6 | | | | | | | | See Combiner Channels 1 thru 8, Cabinet No. 4 for breakdown |
| RECEIVER CHANNEL No. 6 | | | | | | | | See Receiver Channels 1 thru 16, Cabinet No. 4 for breakdown |
| COVER PANEL No. 3 | | | | | | | | See Cover Panel No. 2, Cabinet No. 2 for breakdown |
| VOLTAGE REGULATOR | | | | | | | | See Voltage Regulator, Cabinet No. 2 for breakdown |
| POWER PANEL | | | | | | | | See Power Panel, Cabinet No. 1 for breakdown |
| EXHAUSTER ASSEMBLY ( FAN CENTRIFUGAL) | | | | | | | | See Exhauster Assy Cabinet No. 1 for breakdown |
| CABINET No. 5 | repair | | | X | | | 7 | |
| CABLE ASSEMBLY ELECTRICAL | replace | | X | | | | 7 | |
| | repair | | | X | | | 7 | |
| FILLER PANEL No. 1 | service | | | | | | | |
| SUB GROUP DEMODULATOR | repair | | | X | | | 7 | |
| BAND AMPLIFIER | repair | | | X | | | 7 | |
| CARRIER SUPPLY | | | | | | | | See Carrier Supply Cabinet No. 2 (AN/FGt-2) for breakdown |
| CONVERTER | | | | | | | | See Converter Cabinet No. 2 (AN/FGT-2) for breakdown |

| (1) PART OR COMPONENT | (2) MAINTENANCE FUNCTION | (3) 1ST ECH. | (4) 2ND ECH | (5) 3RD ECH | (6) 4TH ECH | (7) 5TH ECH | (8) TOOLS REQUIRED | (9) REMARKS |
|---|---|---|---|---|---|---|---|---|
| AN/FGC-29 (continued) | | | | | | | | |
| MODULATOR | | | | | | | | See Modulator Cabinet No.2 (AN/FGT-2) for breakdown |
| PLATE SUPPLY | | | | | | | | See Plate Supply, Cabinet No. 2 (AN/FGT-2) for breakdown |
| RECEIVER METER PANEL | repair | | | X | | | 7 | |
| RECEIVER CHANNEL No. 7 | | | | | | | | See Receiver Channels 1 thru 16 Cabinet No. 4 (AN/FGT-2) for breakdown |
| COMBINER CHANNELS Nos. 7 and 8 | | | | | | | | See Combiner Channels 1 thru 8, Cabinet No. 4 for breakdown |
| RECEIVER CHANNEL No. 8 | | | | | | | | See Receiver channnels 1 thru 16 Cabinet No. 4 (AN/FGR-3) for breakdown |
| RECEIVER CHANNEL No. 9 | | | | | | | | See Receiver Channels 1 thru 16 Cabinet No. 4 (AN/FGR-3) for breakdown |
| COMBINER CHANNELS Nos. 9 and 10 | | | | | | | | See Combiner Channels 1 thru 16 Cabinet No. 4 (AN/FGR-3) for breakdown |
| RECEIVER CHANNEL No. 10 | | | | | | | | See Receiver Channels 1 thru 16, Cabinet No. 4 (AN/FGR-3) for breakdown |
| COVER PANEL No. 1 | repair | | | X | | | 7 | |
| POWER PANEL | | | | | | | | See Power Panel Cabinet No. 1 (AN/FGT-2) for breakdown |
| MAIN POWER UNIT | | | | | | | | See Main Power Unit Cabinet No. 1 (AN/FGT-2) for breakdown |
| EXHAUSTER ASSEMBLY (FAN CENTRIFUGAL) | | | | | | | | See Exhauster Assembly Cabinet No. 1 (AN/FGT-2) |
| CABINET No. 6 | repair | | | X | | | 7 | |
| CABLE ASSEMBLY ELECTRICAL | replace | | X | | | | 7 | |
| | repair | | | X | | | 7 | |
| AC POWER SWITCHING PANEL | | | | | | | | See AC Power Switching Panel, Cabinet No.2 (AN/FGT-2) for breakdown |
| RECEIVER CHANNEL No. 11 | | | | | | | | See Receiver Channels 1 thru 16, Cabinet No. 4 (AN/FGR-3) for breakdown |
| COMBINER CHANNELS Nos. 11 and 12 | | | | | | | | See Combiner Channnels 1 thru 16, Cabinet No. 4 (AN/FGR) for breakdown |
| RECEIVER CHANNEL No. 12 | | | | | | | | See Receiver Channels 1 thru 16, Cabinet No. 4, (AN/FGR-3) for breakdown |
| RECEIVER CHANNEL No. 13 | | | | | | | | See Receiver Channels 1 thru 16, Cabinet No. 4, (AN/FGR-3) for breakdown |

| (1) PART OR COMPONENT | (2) MAINTENANCE FUNCTION | (3) 1ST ECH | (4) 2ND ECH | (5) 3RD ECH | (6) 4TH ECH | (7) 5TH ECH | (8) TOOLS REQUIRED | (9) REMARKS |
|---|---|---|---|---|---|---|---|---|
| AN/FGC-29 (continued) | | | | | | | | |
| COMBINER CHANNELS Nos. 13 and 14 | | | | | | | | See Combiner Channels 1 thru 16, Cabinet No. 4, (AN/FGR-3) for breakdown |
| RECEIVER CHANNEL No. 14 | | | | | | | | See Receiver Channels 1 thru 16, Cabinet No. 4, (AN/FGR-3) for breakdown |
| RECEIVER CHANNEL No. 15 | | | | | | | | See Receiver Channels 1 thru 16, Cabinet No. 15, (AN/FGR-3) for breakdown |
| COMBINER CHANNELS Nos. 15 and 16 | | | | | | | | See Combiner Channels 1 thru 16, Cabinet No. 4, (AN/FGR-3) for breakdown |
| RECEIVER CHANNEL No. 16 | | | | | | | | See Receiver Channels 1 thru 16, Cabinet No. 4, (AN/FGR-3) for breakdown |
| COVER PANEL No. 3 | | | | | | | | See Cover Panel No. 3, Cabinet No. 2, (AN/FGT-2) for breakdown |
| VOLTAGE REGULATOR | | | | | | | | See Voltage Regulator, Cabinet No. 2, (AN/FGT-2) for breakdown |
| POWER PANEL | | | | | | | | See Power Panel, Cabinet No. 1, (AN/FGT-2) for breakdown |
| EXHAUSTER ASSEMBLY (FAN CENTRIFUGAL) | | | | | | | | See Exhauster Assembly Cabinet No. 1 (AN/FGT-2) for breakdown |

## ALLOCATION OF TOOLS FOR MAINTENANCE FUNCTIONS

| (1) TOOLS REQUIRED FOR MAINTENANCE FUNCTIONS | (2) 1ST ECH | (3) 2ND ECH | (4) 3RD ECH | (5) 4TH ECH | (6) 5TH ECH | (7) TOOL CODE | (8) REMARKS |
|---|---|---|---|---|---|---|---|
| AN/FGC-29 (continued) | | | | | | | |
| MULTIMETER TS-352/U | | † | † | † | † | 1 | |
| TEST SET ELECTRON TUBE TV-7/U | | † | † | † | | 2 | |
| TEST SET ELECTRON TUBE TV-2/U | | | | | † | 3 | Replaces TV-7/U at 5th echelon only |
| TEST SET TS-140/PCM | | | † | † | † | 4 | |
| ELECTRONIC VOLTMETER ME-30/U | | | † | † | † | 5 | |
| FREQUENCY METER AN/TSM-16 | | | † | † | † | 6 | |
| TOOL EQUIPMENT TE-123 | | † | † | † | † | 7 | |

By Order of the Secretary of the Army:

HAROLD K. JOHNSON,
*General, United States Army,*
*Chief of Staff.*

Official:
J. C. LAMBERT,
*Major General, United States Army,*
*The Adjutant General.*

Distribution:

*Active Army:*

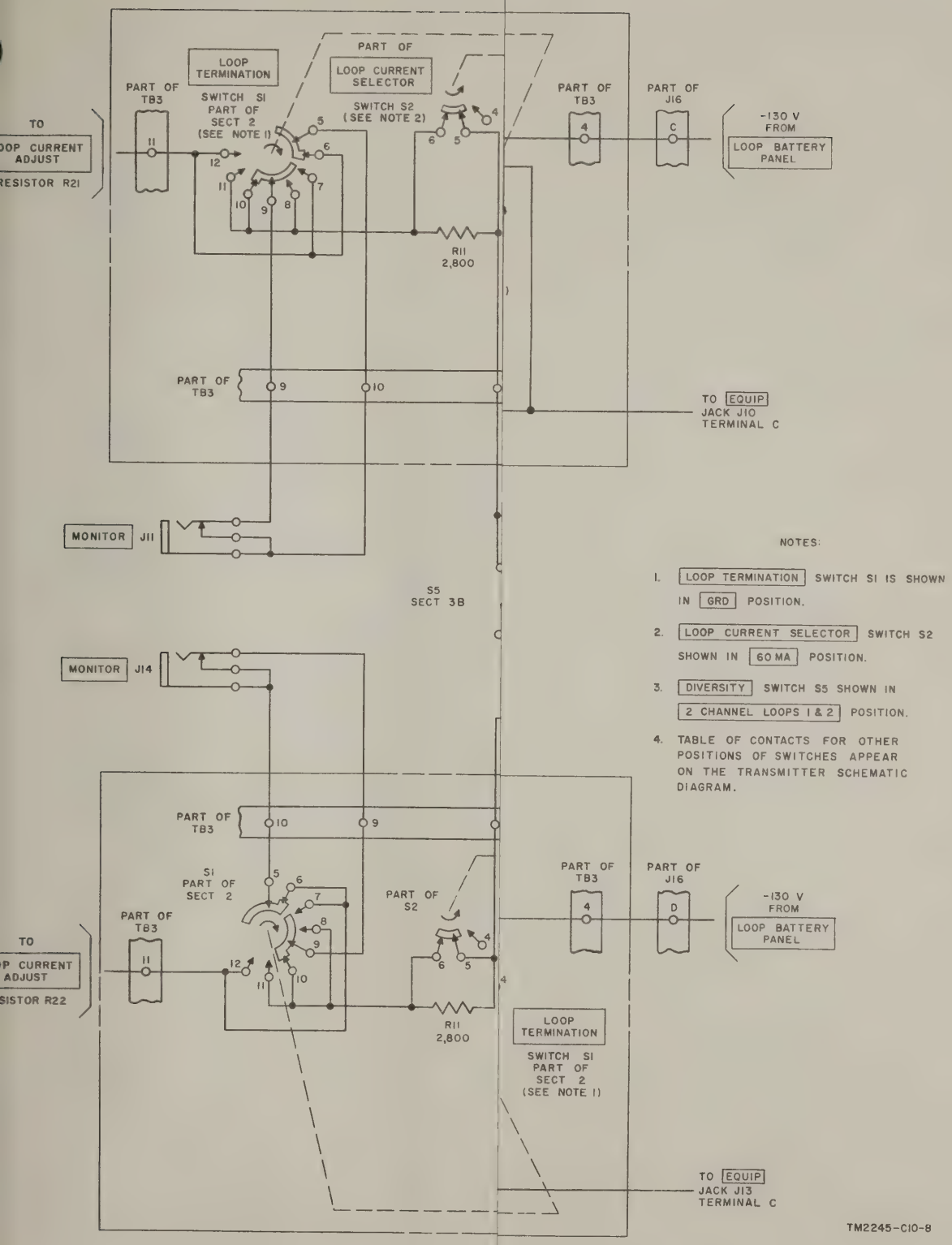
USASA (2)
CNGB (1)
CC–E (7)
Dir of Trans (1)
CofEngrs (1)
TSG (1)
CofSptS (1)
USACDCEA (1)
USACDCCBRA (1)
USACDCCEA (1)
USACDCCEA:
  Ft Huachuca (1)
USACDCOA (1)
USACDCQMA (1)
USACDCTA (1)
USACDCADA (1)
USACDCARMA (1)
USACDCAVNA (1)
USACDCARTYA (1)
USACDCSWA (1)
USAMC (5)
USCONARC (5)
ARADCOM (5)
ARADCOM Rgn (2)
OS Maj Comd (4)
LOGCOMD (2)
USAMICOM (4)
USASMC (2)
USASCC (4)
MDW (1)
Armies (2)
Corps (2)
USAC (3)
Svc Colleges (2)
Br Svc Sch (2)
USASTC (2)
USATC Armor (2)
USATC Engr (2)
USATC Inf (2)
WRAMC (1)
Army Pic Cen (2)
USACDCEC (10)
GENDEP (2)
Sig Sec GENDEP (5)
Sig Dep (12)
A Dep (2) except
  LBAD (14)
  SAAD (30)
  TOAD (14)
  FTWOAD (10)
  LEAD (7)
  SHAD (3)
  NAAD (5)
  SVAD (5)
  CHAD (3)
  ATAD (10)
Instl (2) except
  Ft Monmouth (70)
  Ft Hancock (4)
  Ft Gordon (10)
  Ft Huachuca (10)
  Ft Carson (25)
  Ft Knox (12)
WSMR (5)
Sig FLDMS (2)
AMS (1)
USAERDAA (2)
USAERDAW (13)
USACRREL (2)
Units org under fol TOE:
  (2 copies each)
  11–27
  11–57
  11–97
  11–98
  11–117
  11–127
  11–155
  11–157
  11–158
  11–500 (AA–AC)
  11–592
  11–597

*NG:* None.

*USAR:* None.

For explanation of abbreviations used, see AR 320–50.

☆ U.S. Government Printing Office: 1966— 250-501/5242A


LOOP TERMINATION
PART OF LOOP CURRENT SELECTOR
PART OF TB3
SWITCH S1 PART OF SECT 2 (SEE NOTE 1)
SWITCH S2 (SEE NOTE 2)
PART OF TB3
PART OF J16
-130 V FROM LOOP BATTERY PANEL
TO OOP CURRENT ADJUST RESISTOR R21
R11 2,800
PART OF TB3
TO EQUIP JACK J10 TERMINAL C
MONITOR J11
S5 SECT 3B
MONITOR J14
PART OF TB3
S1 PART OF SECT 2
PART OF S2
PART OF TB3
PART OF J16
-130 V FROM LOOP BATTERY PANEL
TO P CURRENT ADJUST SISTOR R22
R11 2,800
LOOP TERMINATION
SWITCH S1 PART OF SECT 2 (SEE NOTE 1)
TO EQUIP JACK J13 TERMINAL C

NOTES:

1. LOOP TERMINATION SWITCH S1 IS SHOWN IN GRD POSITION.
2. LOOP CURRENT SELECTOR SWITCH S2 SHOWN IN 60 MA POSITION.
3. DIVERSITY SWITCH S5 SHOWN IN 2 CHANNEL LOOPS 1 & 2 POSITION.
4. TABLE OF CONTACTS FOR OTHER POSITIONS OF SWITCHES APPEAR ON THE TRANSMITTER SCHEMATIC DIAGRAM.

TM2245-C10-8

By Order of the Secretary of the Army:

HAROLD K. JOHNSON,
*General, United States Army,*
*Chief of Staff.*

Official:
J. C. LAMBERT,
*Major General, United States Army,*
*The Adjutant General.*

Distribution:

*Active Army:*

USASA (2)
CNGB (1)
CC–E (7)
Dir of Trans (1)
CofEngrs (1)
TSG (1)
CofSptS (1)
USACDCEA (1)
USACDCCBRA (1)
USACDCCEA (1)
USACDCCEA:
  Ft Huachuca (1)
USACDCOA (1)
USACDCQMA (1)
USACDCTA (1)
USACDCADA (1)
USACDCARMA (1)
USACDCAVNA (1)
USACDCARTYA (1)
USACDCSWA (1)
USAMC (5)
USCONARC (5)
ARADCOM (5)
ARADCOM Rgn (2)
OS Maj Comd (4)
LOGCOMD (2)
USAMICOM (4)
USASMC (2)
USASCC (4)
MDW (1)
Armies (2)
Corps (2)
USAC (3)
Svc Colleges (2)
Br Svc Sch (2)
USASTC (2)
USATC Armor (2)
USATC Engr (2)
USATC Inf (2)
WRAMC (1)
Army Pic Cen (2)
USACDCEC (10)
GENDEP (2)
Sig Sec GENDEP (5)
Sig Dep (12)
A Dep (2) except
  LBAD (14)
  SAAD (30)
  TOAD (14)
  FTWOAD (10)
  LEAD (7)
  SHAD (3)
  NAAD (5)
  SVAD (5)
  CHAD (3)
  ATAD (10)
Instl (2) except
  Ft Monmouth (70)
  Ft Hancock (4)
  Ft Gordon (10)
  Ft Huachuca (10)
  Ft Carson (25)
  Ft Knox (12)
WSMR (5)
Sig FLDMS (2)
AMS (1)
USAERDAA (2)
USAERDAW (13)
USACRREL (2)
Units org under fol TOE:
  (2 copies each)
  11–27
  11–57
  11–97
  11–98
  11–117
  11–127
  11–155
  11–157
  11–158
  11–500 (AA–AC)
  11–592
  11–597

*NG:* None.

*USAR:* None.

For explanation of abbreviations used, see AR 320–50.

☆ U.S. Government Printing Office: 1966— 250-501/5242A

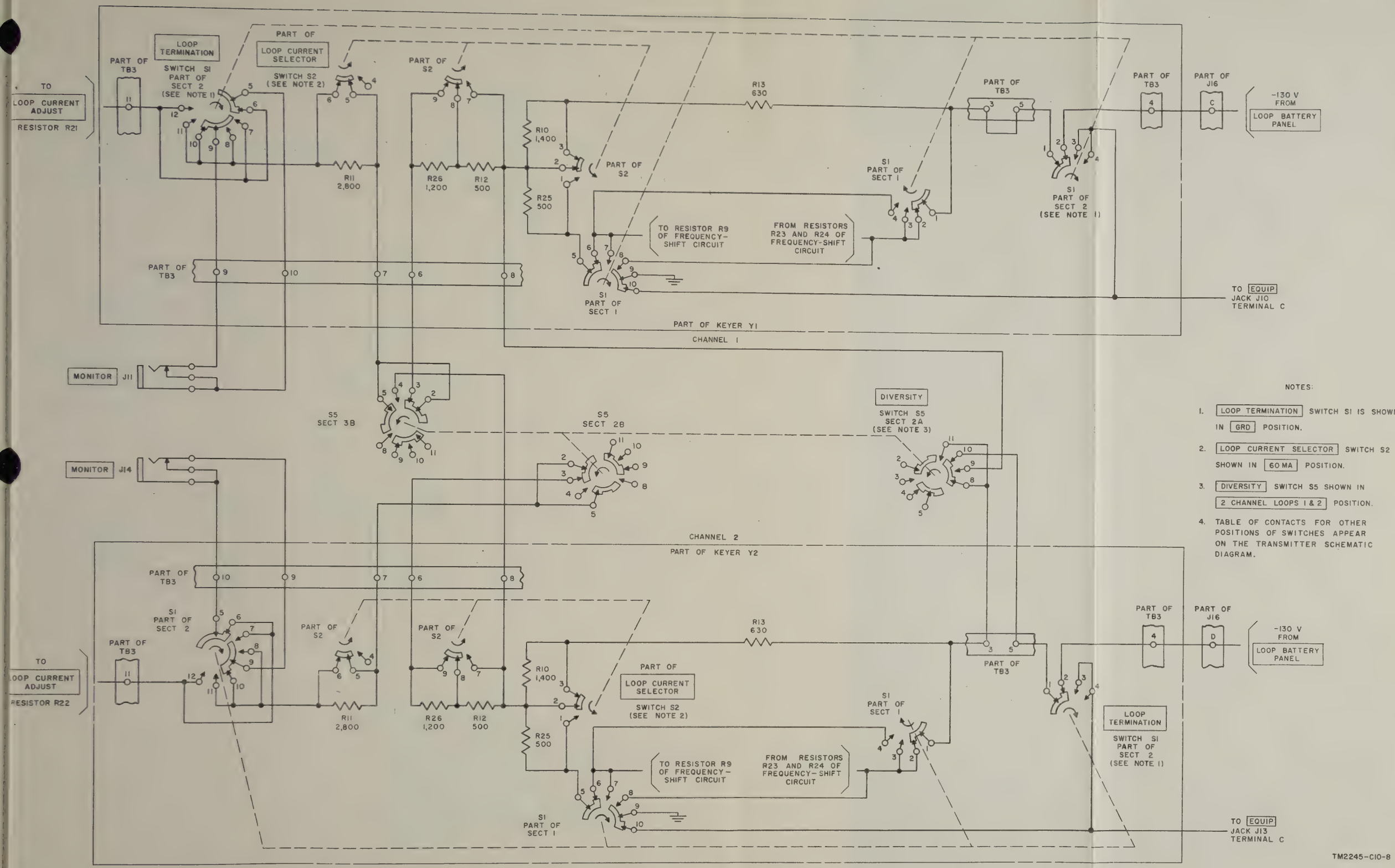
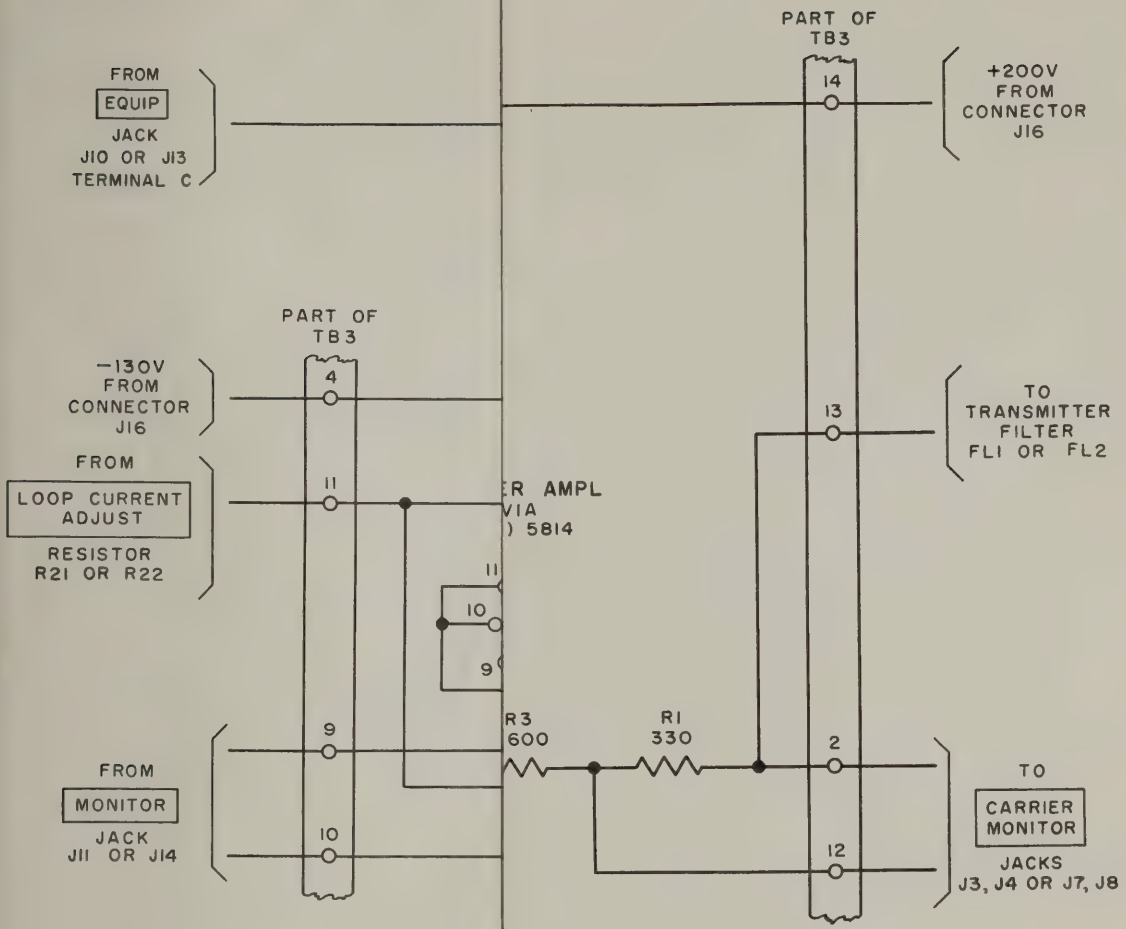

TO LOOP CURRENT ADJUST RESISTOR R21
PART OF TB3
LOOP TERMINATION
SWITCH S1 PART OF SECT 2 (SEE NOTE 1)
PART OF LOOP CURRENT SELECTOR
SWITCH S2 (SEE NOTE 2)
PART OF S2
R11 2,800
R26 1,200
R12 500
R10 1,400
R25 500
R13 630
PART OF S2
S1 PART OF SECT 1
TO RESISTOR R9 OF FREQUENCY-SHIFT CIRCUIT
FROM RESISTORS R23 AND R24 OF FREQUENCY-SHIFT CIRCUIT
PART OF TB3
S1 PART OF SECT 1
S1 PART OF SECT 2 (SEE NOTE 1)
PART OF TB3
PART OF J16
-130 V FROM LOOP BATTERY PANEL
TO EQUIP JACK J10 TERMINAL C
PART OF KEYER Y1
CHANNEL 1
MONITOR J11
MONITOR J14
S5 SECT 3B
S5 SECT 2B
DIVERSITY
SWITCH S5 SECT 2A (SEE NOTE 3)
CHANNEL 2
PART OF KEYER Y2
PART OF TB3
TO LOOP CURRENT ADJUST RESISTOR R22
S1 PART OF SECT 2
PART OF TB3
PART OF S2
PART OF S2
R11 2,800
R26 1,200
R12 500
R10 1,400
R25 500
R13 630
PART OF LOOP CURRENT SELECTOR SWITCH S2 (SEE NOTE 2)
TO RESISTOR R9 OF FREQUENCY-SHIFT CIRCUIT
FROM RESISTORS R23 AND R24 OF FREQUENCY-SHIFT CIRCUIT
S1 PART OF SECT 1
PART OF TB3
PART OF TB3
PART OF J16
-130 V FROM LOOP BATTERY PANEL
LOOP TERMINATION SWITCH S1 PART OF SECT 2 (SEE NOTE 1)
TO EQUIP JACK J13 TERMINAL C
NOTES:
1. LOOP TERMINATION SWITCH S1 IS SHOWN IN GRD POSITION.
2. LOOP CURRENT SELECTOR SWITCH S2 SHOWN IN 60 MA POSITION.
3. DIVERSITY SWITCH S5 SHOWN IN 2 CHANNEL LOOPS 1 & 2 POSITION.
4. TABLE OF CONTACTS FOR OTHER POSITIONS OF SWITCHES APPEAR ON THE TRANSMITTER SCHEMATIC DIAGRAM.
TM2245-C10-8

*Figure 79. Transmitter, switching circuits, simplified, schematic diagram.*




NOTES:

1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UUF.
2. IN EVEN CHANNELS OF TRANSMITTERS, TERMINALS 5 AND 3 OF TERMINAL BOARD TB3 ARE CONNECTED TO DIVERSITY SWITCH S5. IN ODD CHANNELS TERMINAL 5 IS CONNECTED TO TERMINAL 3.
3. FOR EXTERNAL CONNECTIONS REFER TO SCHEMATIC DIAGRAM OF TRANSMITTER.

TM2245-C10-9

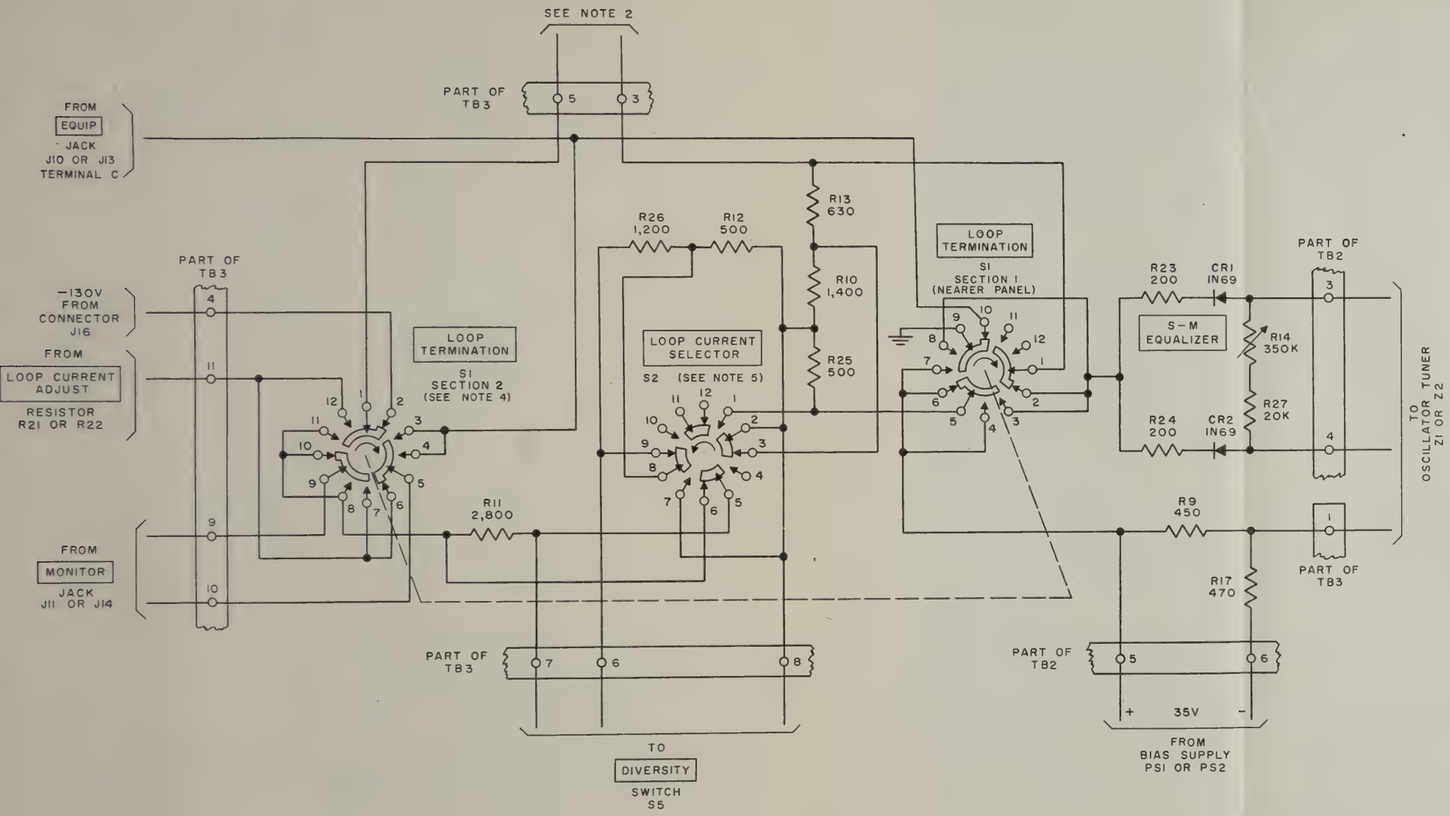
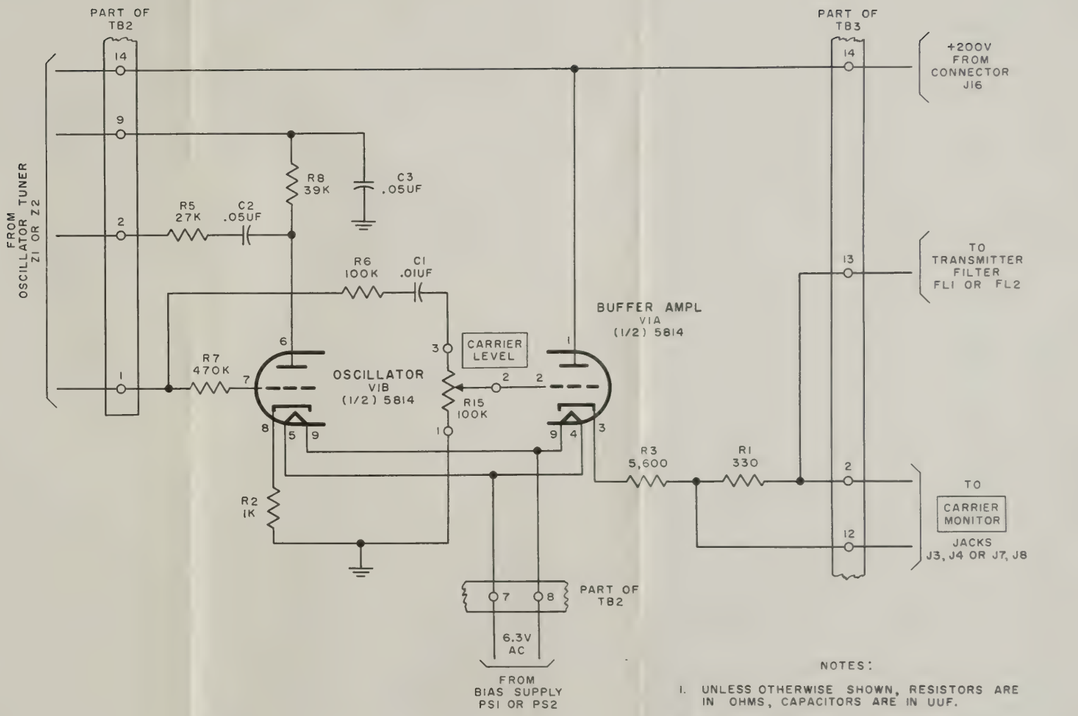



*Figure 81. Transmitter, keyer, schematic diagram.*



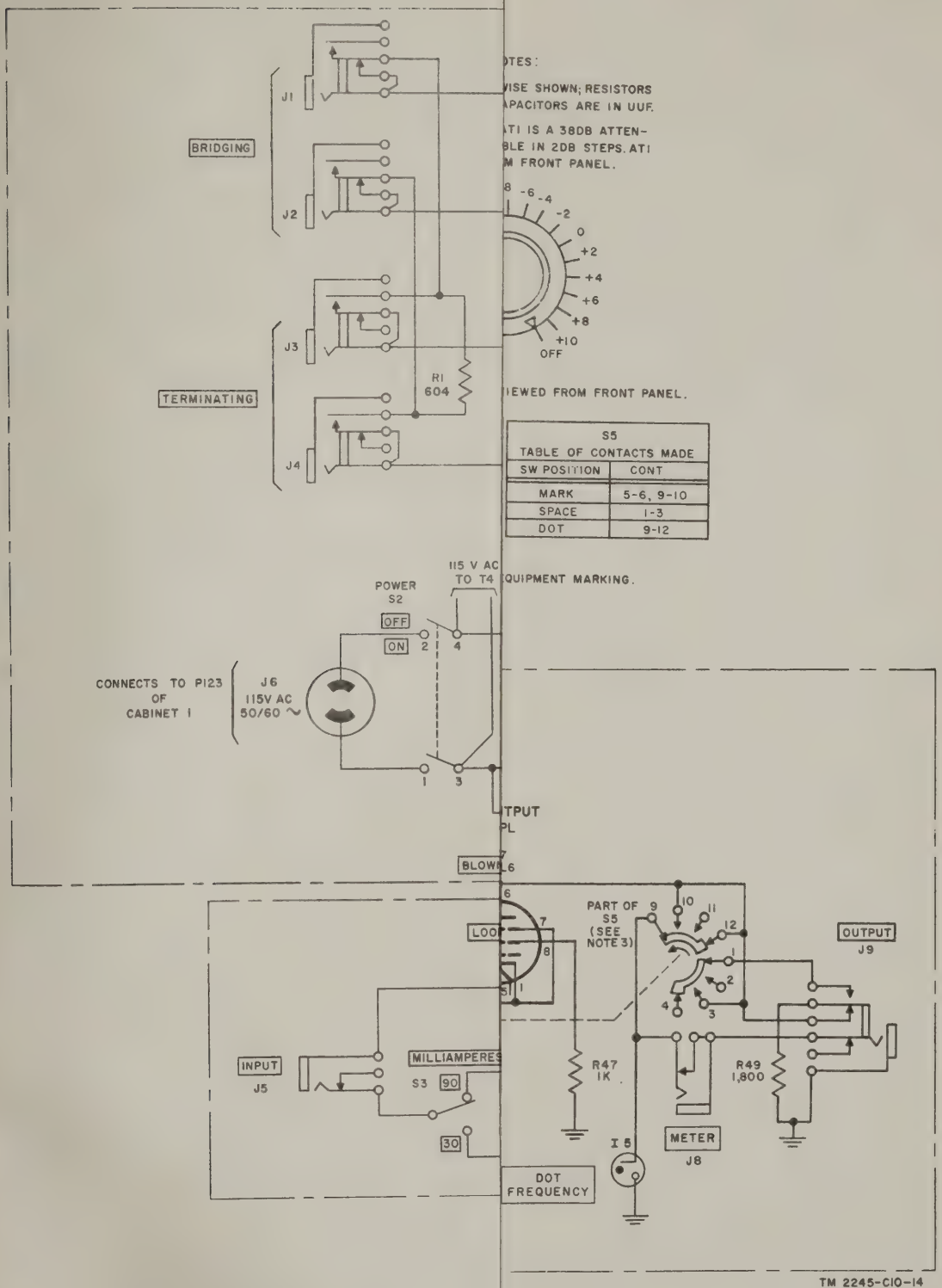

4. LOOP TERMINATION SWITCH S1 SHOWN IN GRD POSITION.

5. LOOP CURRENT SELECTOR SWITCH S2 SHOWN IN 60 MA POSITION.

NOTES:

1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UUF.
2. IN EVEN CHANNELS OF TRANSMITTERS, TERMINALS 5 AND 3 OF TERMINAL BOARD TB3 ARE CONNECTED TO DIVERSITY SWITCH S5. IN ODD CHANNELS TERMINAL 5 IS CONNECTED TO TERMINAL 3.
3. FOR EXTERNAL CONNECTIONS REFER TO SCHEMATIC DIAGRAM OF TRANSMITTER.

TM2245-C10-9




TES:

ISE SHOWN; RESISTORS
APACITORS ARE IN UUF.

TI IS A 38DB ATTEN-
BLE IN 2DB STEPS. ATI
M FRONT PANEL.

EWED FROM FRONT PANEL.

| S5<br>TABLE OF CONTACTS MADE | |
|---|---|
| SW POSITION | CONT |
| MARK | 5-6, 9-10 |
| SPACE | 1-3 |
| DOT | 9-12 |

QUIPMENT MARKING.

TPUT
PL

TM 2245-C10-14

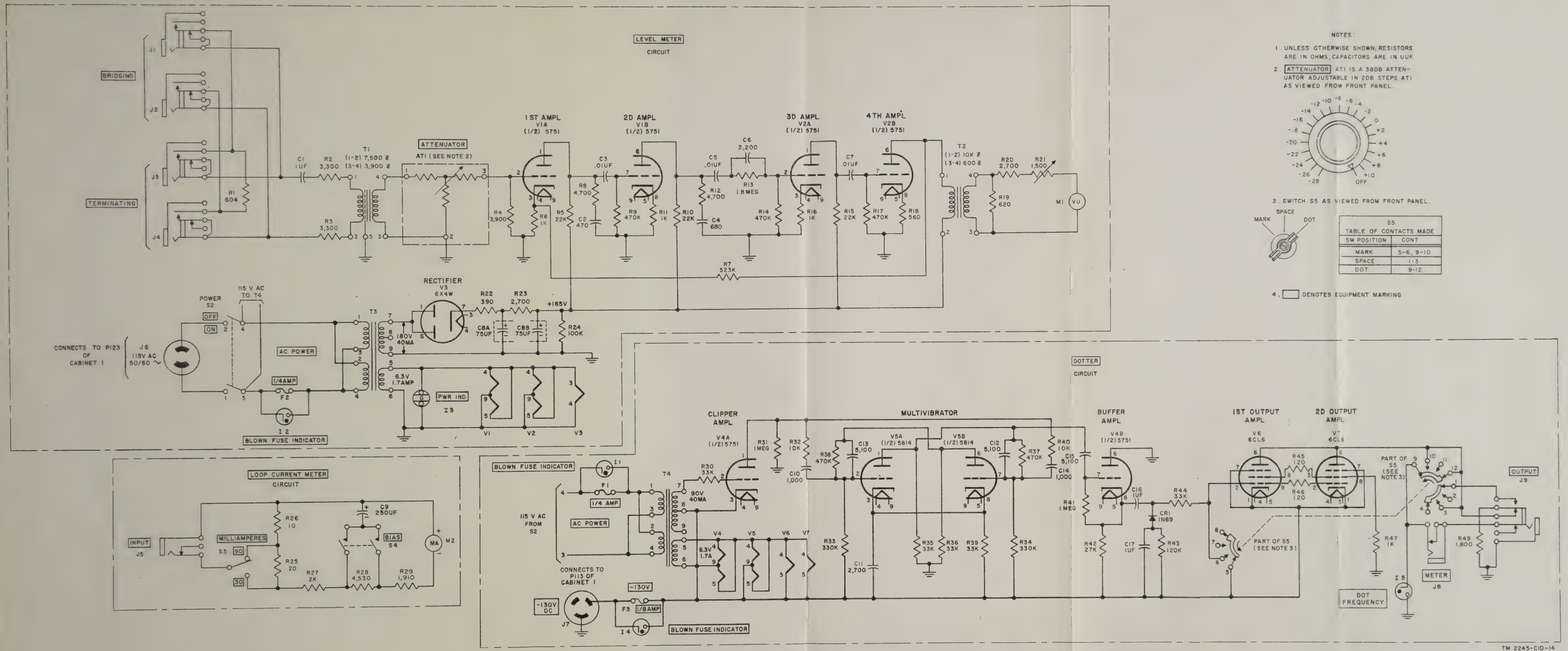
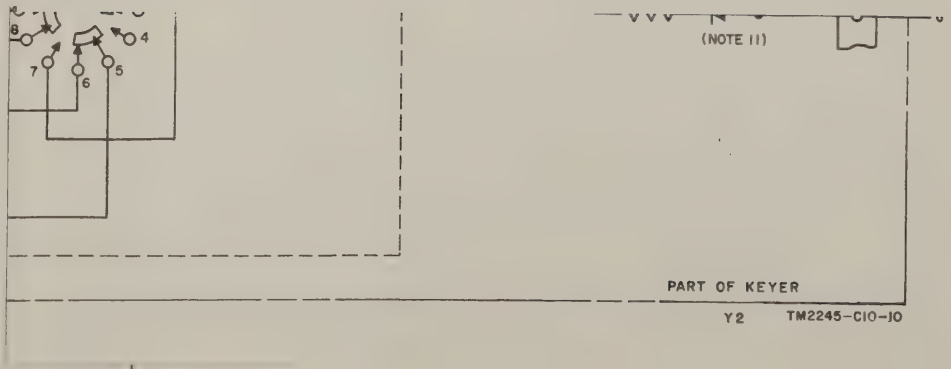



*Figure 153.1. TRANSMITTER METER PANEL bearing Order No. 374–Phila–54 with serial numbers 28 through 113.*


8
4
7
6
5
(NOTE 11)
PART OF KEYER
Y2
TM2245-C10-10

NOTES:

1. WIRES NOT OTHERWISE SPECIFIED ARE 22 GAGE WITH NYLON JACKET.
2. BS DENOTES 22 GAGE TINNED, ANNEALED COPPER WIRING.
3. U DENOTES SHIELDED 22 GAGE WIRE WITH EXTRUDED NYLON JACKET.
4. PE DENOTES 22 GAGE WIRE WITH POLYETHYLENE INSULATION AND NYLON JACKET. THESE WIRES ARE RUN DIRECT.
5. ⊏⊐ DENOTES SHIELDED CONNECTION.
6. P18 DENOTES TWISTED PAIR 18 GAGE WITH NYLON JACKET.
7. P20 DENOTES TWISTED PAIR 20 GAGE WITH NYLON JACKET.
8. SWITCH S5 IS A SWITCH ASSEMBLY CONSISTING OF A ROTARY SOLENOID AND THREE SWITCH SECTIONS.
9. [LOOP TERMINATION] SWITCH S1 OF KEYER Y1.
10. [LOOP TERMINATION] SWITCH S1 OF KEYER Y2.

* DISCONNECTED TO PERFORM MWO.

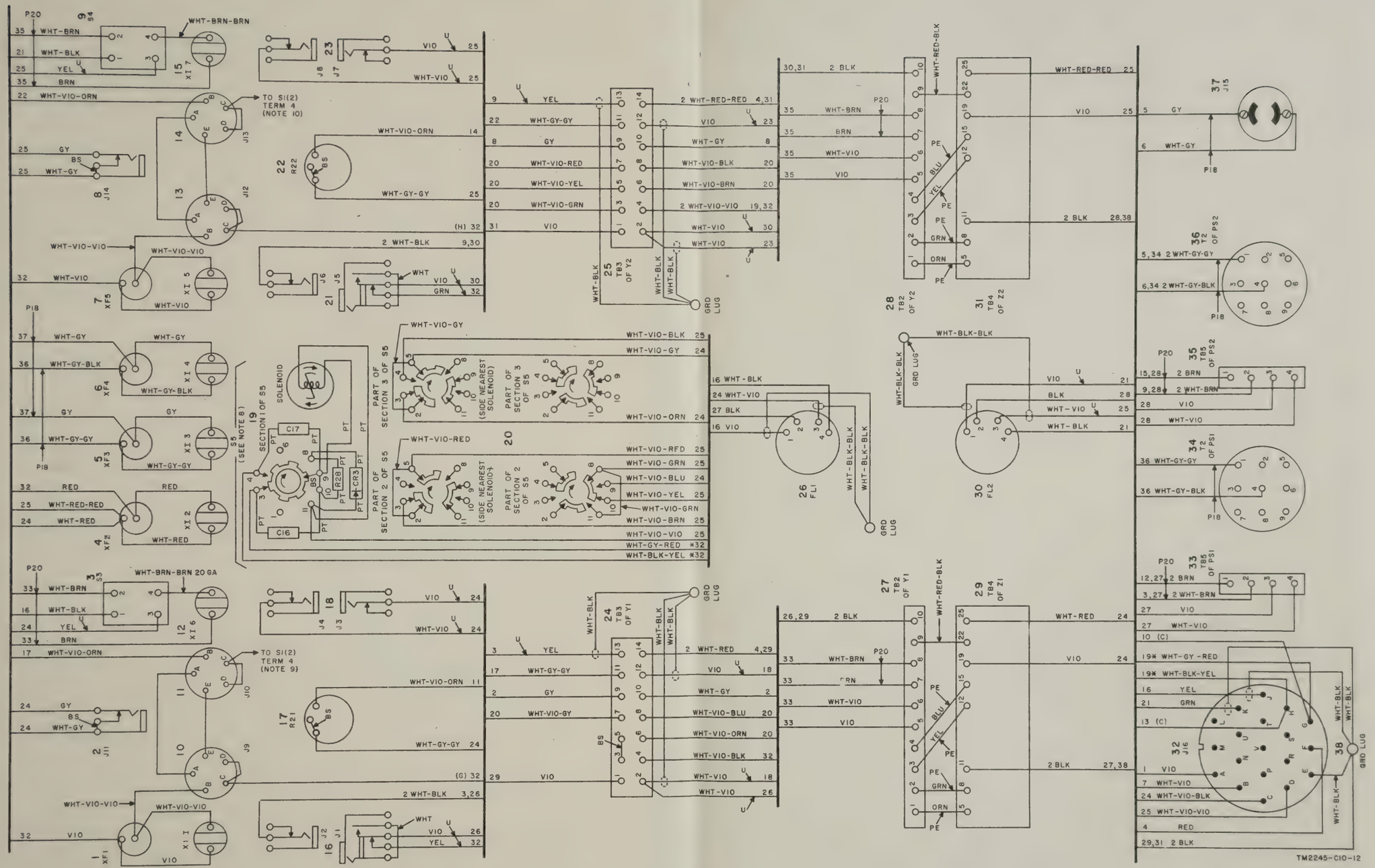
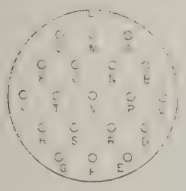



*Figure 268. Transmitter wiring diagram.*

NOTES:

1. P111 AND P112 VIEWED FROM WIRING END

2. P-3 THROUGH P-10 VIEWED FROM WIRING



3. W111 THROUGH W120 ARE VINYL JACKETE WITH TEN 20 GAGE STRANDED TINNED C CONDUCTORS, VINYL INSULATED.

4. W1 AND W121 THROUGH W130 ARE MOLDE CABLES WITH 16 GAGE STRANDED TINNE CONDUCTORS, RUBBER INSULATED.

5. W136 IS A MOLDED RUBBER CABLE WITH STRANDED TINNED COPPER CONDUCTORS INSULATED.

6. WIRES NOT OTHERWISE SPECIFIED ARE 2 WITH NYLON JACKET.

7. U DENOTES SHIELDED 22 GAGE WIRE W EXTRUDED NYLON JACKET.

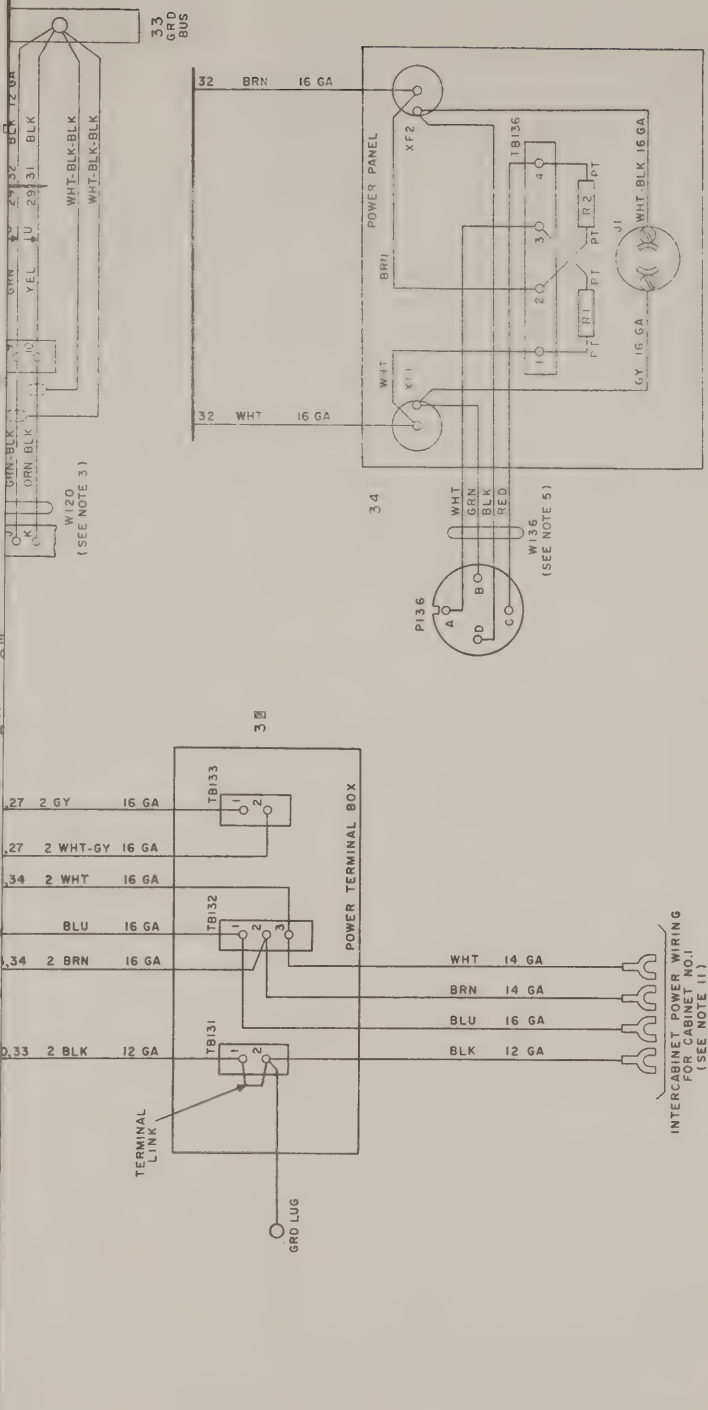
8. ⊂— DENOTES SHIELDED CONNECTIO

9. P DENOTES TWISTED PAIR

10. PT DENOTES LEADS PART OF APPARATUS

11. FOR TERMINATION OF THESE LEADS IN F TERMINAL BOX OF CABINET 1, REFER TO INTERCABINET CORDING DIAGRAM OF TH TERMINAL.

12. DISCONNECTED AND TAPED TO PERFORM



NOTES:

1. UNLESS OTHERWISE SHOWN; RESISTORS ARE IN OHMS CAPACITORS ARE IN UUF.
2. AC SIGNAL PATH SHOWN IN HEAVY LINES.
3. CONNECTOR J16 AS VIEWED FROM PIN END.

4. SWITCH S1 VIEWED FROM KNOB END.

LOOP TERMINATION

| S1 TABLE OF CONTACTS MADE | | |
|---|---|---|
| SWITCH POSITION | | CONTACT |
| OPEN | | |
| GRD | | 1-2,6-5,9-10 |
| POS | | 1-3,7-5,9-11 |
| NEG | | 1-4,5-8,12-9 |

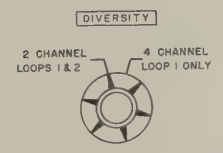
5. SWITCH S2 VIEWED FROM KNOB END.

LOOP CURRENT SELECTOR

| S2 TABLE OF CONTACTS MADE | |
|---|---|
| SW POSITION | CONTACT |
| 60 MA | 2-3,6-5, 9-8 |
| 20 MA | 2-1, 8-7 |

6. SWITCH S5 VIEWED FROM KNOB END.

DIVERSITY




| S5 TABLE OF CONTACTS MADE | | | | |
|---|---|---|---|---|
| SWITCH POSITION | SECTION 1 | 2A | 2B | 3 |
| 2 CHANNEL LOOPS 1&2 | 9-3 | 8 OR 11-10 | 2 OR 5-3 | 2 OR 5-3 |
| 4 CHANNEL LOOP 1 ONLY | 9-4 | 8 OR 11-9 | 2 OR 5-4 | 2 OR 5-4 |

7.

| CHANNELS | OSC TUNER DESIGNATION | XMTR FILTER OR TUNED NETWORK DESIGNATION | C11 (UUF) | C12 (UUF) | C13 (UUF) | C14 (UUF) | R18 (OHMS) |
|---|---|---|---|---|---|---|---|
| 1 AND 16 | 1/16 | 1/16 1,785 CPS | 1,600 | 820 | 390 | 200 | 30K |
| 2 AND 15 | 2/15 | 2/15 2,975 CPS | 820 | 390 | 200 | 100 | 39K |
| 3 AND 14 | 3/14 | 3/14 1,955 CPS | 1,600 | 820 | 390 | 200 | 39K |
| 4 AND 13 | 4/13 | 4/13 2,805 CPS | 820 | 390 | 200 | 100 | 30K |
| 5 AND 12 | 5/12 | 5/12 2,125 CPS | 1,600 | 820 | 390 | 200 | 20K |
| 6 AND 11 | 6/11 | 6/11 2,635 CPS | 820 | 390 | 200 | 100 | 20K |
| 7 AND 10 | 7/10 | 7/10 2,295 CPS | 1,600 | 820 | 390 | 200 | 30K |
| 8 AND 9 | 8/9 | 8/9 2,465 CPS | 1,600 | 820 | 390 | 200 | 39K |

8. WIRING ADDED AS REQUIRED FOR RESONANCE.
9. ▭ DENOTES EQUIPMENT MARKING.
10. FOR EXTERNAL CONNECTIONS SEE TABLE BELOW.

| EXT CONNECTIONS | REFER TO SCHEMATIC DIAGRAM FOR |
|---|---|
| INPUT AND OUTPUT | TRANSMITTING TERMINAL, ARRANGED FOR 6 KC OPERATION |
| B+ VOLTAGE | TRANSMITTING TERMINAL, B+ VOLTAGE DISTRIBUTION |
| AC POWER | TRANSMITTING TERMINAL, AC POWER DISTRIBUTION |
| LOOP BAT. VOLTAGE | TRANSMITTING TERMINAL, LOOP BATTERY DISTRIBUTION |

11. SOME EQUIPMENTS HAVE BEEN MODIFIED TO PROVIDE INVERTED MARKING AND SPACING OUTPUTS BY REVERSING DIRECTIONS OF DIODES CR1 AND CR2 (PLATE AND CATHODE CONNECTIONS REVERSED).

*Figure 254. Transmitter, schematic diagram (sheet 1 of 2).*

NOTES:

1. WIRES NOT OTHERWISE SPECIFIED AR
WITH NYLON JACKET.
2. BS DENOTES 22 GAGE TINNED, ANNEA
WIRING
3. U DENOTES SHIELDED 22 GAGE WIRE
EXTRUDED NYLON JACKET.
4. PE DENOTES 22 GAGE WIRE WITH PO
INSULATION AND NYLON JACKET. THE
ARE RUN DIRECT.
5 ⊂⊃—DENOTES SHIELDED CONNECTI
6 P18 DENOTES TWISTED PAIR 18 GAGE
JACKET.
7. P20 DENOTES TWISTED PAIR 20 GAG
NYLON JACKET.
8 SWITCH S5 IS A SWITCH ASSEMBLY
OF A ROTARY SOLENOID AND THREE S
SECTIONS
9. LOOP TERMINATION SWITCH S1 OF K
10. LOOP TERMINATION SWITCH S1 OF KE
* DISCONNECTED TO PERFORM MWO.

NOTES:

1. P111 AND P112 VIEWED FROM WIRING END

2. P113 THROUGH P120 VIEWED FROM WIRING END

3. W111 THROUGH W120 ARE VINYL JACKETED CABLES WITH TEN 20 GAGE STRANDED TINNED COPPER CONDUCTORS, VINYL INSULATED.

4. W1 AND W121 THROUGH W130 ARE MOLDED RUBBER CABLES WITH 16 GAGE STRANDED TINNED COPPER CONDUCTORS, RUBBER INSULATED.

5. W136 IS A MOLDED RUBBER CABLE WITH 20 GAGE STRANDED TINNED COPPER CONDUCTORS RUBBER INSULATED.

6. WIRES NOT OTHERWISE SPECIFIED ARE 22 GAGE WITH NYLON JACKET.

7. U DENOTES SHIELDED 22 GAGE WIRE WITH EXTRUDED NYLON JACKET.

8. DENOTES SHIELDED CONNECTION.

9. P DENOTES TWISTED PAIR

10. PT DENOTES LEADS PART OF APPARATUS.

11. FOR TERMINATION OF THESE LEADS IN POWER TERMINAL BOX OF CABINET 1, REFER TO INTERCABINET CORDING DIAGRAM OF TRANSMITTING TERMINAL.

12. DISCONNECTED AND TAPED TO PERFORM MWO.

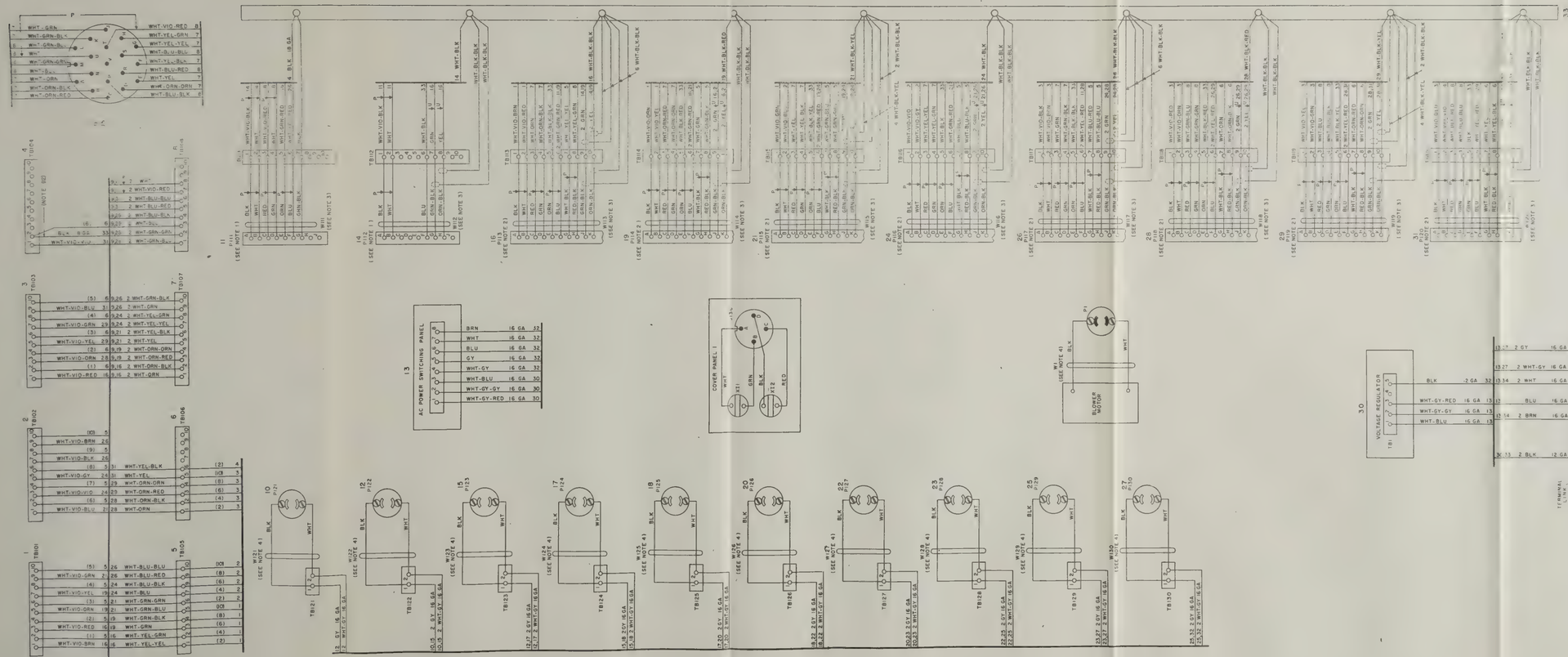



*Figure 263. Cabinet 2 wiring diagram.*

TECHNICAL DATA



TECHNICAL MANUAL
No. 11-2245

DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., *3 August 1956*

# TELEGRAPH TERMINAL AN/FGC-29


| | | Paragraph | Page |
|---|---|---|---|
| CHAPTER 1. | INTRODUCTION | | |
| Section I. | General | 1, 2 | 1 |
| II. | Description and data | 3–36 | 1 |
| CHAPTER 2. | INSTALLATION | | |
| Section I. | System planning considerations | 37–44 | 23 |
| II. | Service upon receipt of equipment | 45–61 | 35 |
| CHAPTER 3. | OPERATION | | |
| Section I. | Controls and instruments | 62–81 | 64 |
| II. | Initial adjustments and tests | 82–94 | 106 |
| III. | Equipment lineup procedure | 95–106 | 112 |
| IV. | System lineup procedure | 107–113 | 124 |
| V. | Operating procedure | 114–122 | 130 |
| VI. | Operation under unusual conditions | 123–126 | 138 |
| CHAPTER 4. | THEORY | | |
| Section I. | Introduction | 127–134 | 139 |
| II. | General theory of AN/FGC–29 terminal | 135–141 | 142 |
| III. | Theory of transmitter | 142–154 | 147 |
| IV. | Theory of SUBGROUP MODULATOR | 155–166 | 158 |
| V. | Theory of LEVEL CONTROL & PLATE SUPPLY | 167–171 | 178 |
| VI. | Theory of SUBGROUP DEMODULATOR | 172–179 | 182 |
| VII. | Theory of receiver | 180–187 | 188 |
| VIII. | Theory of combiner | 188–193 | 203 |
| IX. | Theory of Multiplexer TD–97/FGT–2, Demultiplexer TD–98/FGR–3, and Audio Frequency Amplifier AM–911/FG | 194–197 | 217 |
| X. | Theory of transmitting terminal | 198–202 | 222 |
| XI. | Theory of receiving terminal | 203–206 | 227 |
| XII. | Theory of remote control circuits | 207–209 | 236 |
| XIII. | Theory of ac power distribution | 210–215 | 239 |
| XIV. | Theory of dc power distribution circuits | 216–223 | 247 |
| XV. | Theory of auxiliary components | 224–230 | 254 |
| CHAPTER 5. | MAINTENANCE | | |
| Section I. | Preventive maintenance services | 231, 232 | 270 |
| II. | Lubrication | 233–235 | 270 |
| III. | Weatherproofing | 236, 237 | 271 |
| IV. | Troubleshooting | 238–250 | 271 |
| V. | Trouble sectionalization, Telegraph Terminal AN/FGC–29 | 251–257 | 282 |
| VI. | Troubleshooting, transmitter | 258–266 | 297 |
| VII. | Troubleshooting, SUBGROUP MODULATOR | 267–275 | 315 |
| VIII. | Troubleshooting, LEVEL CONTROL & PLATE SUPPLY | 276–281 | 336 |
| IX. | Troubleshooting, 3KC SEND BAND TEST PANEL | 282, 283 | 343, 344 |
| X. | Troubleshooting, Transformer Assembly TF–206/FG | 284, 285 | 346, 347 |
| XI. | Troubleshooting, 3KC RECEIVE BAND TEST PANEL | 286, 287 | 348 |
| XII. | Troubleshooting, SUBGROUP DEMODULATOR | 288–294 | 350 |
| XIII. | Troubleshooting, receiver | 295–303 | 359 |
| XIV. | Troubleshooting, combiner | 304–309 | 375 |
| XV. | Troubleshooting, AC POWER SWITCHING PANEL | 310–312 | 389 |
| XVI. | Troubleshooting, VOLTAGE REGULATOR | 313–316 | 392 |
| XVII. | Troubleshooting, LOOP BATTERY PANEL | 317–319 | 396 |
| XVIII. | Troubleshooting, LOOP BATTERY SUPPLY | 320–323 | 399 |
| XIX. | Troubleshooting, TRANSMITTER METER PANEL | 324–327 | 402 |
| XX. | Troubleshooting, RECEIVER METER PANEL | 328–331 | 408 |
| XXI. | Troubleshooting, DIVERSITY ALIGNMENT PANEL | 332–335 | 414 |
| XXII. | Miscellaneous troubleshooting procedures | 336–342 | 419 |
| XXIII. | Repairs | 343–345 | 423 |
| XXIV. | Final tests | 346–348 | 424 |
| CHAPTER 6. | SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE | | |
| Section I. | Shipment and limited storage | 349, 350 | 426, 427 |
| II. | Demolition to prevent enemy use | 351, 352 | 427 |
| INDEX | | | |


TECHNICAL DATA

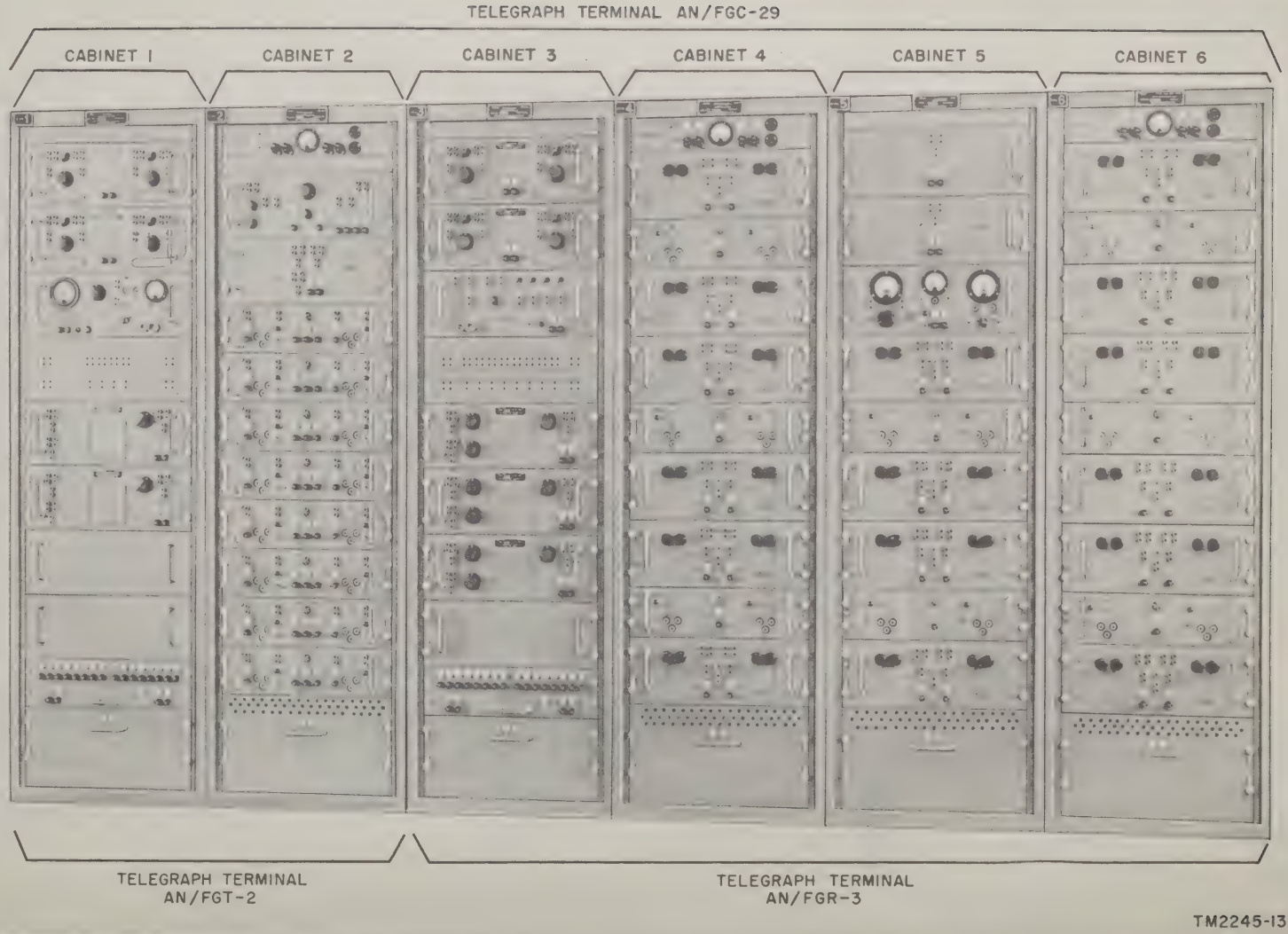



*Figure 1. Telegraph Terminal AN FGC-29.*

# CHAPTER 1
# INTRODUCTION

## Section I. GENERAL

### 1. Scope

*a.* This manual contains information for the installation, operation, theory, and maintenance of Telegraph Terminal AN/FGC–29 (fig. 1).

*b.* Multiplexer TD–97/FGT–2, Demultiplexer TD–98/FGR–3, and Audio Frequency Amplifier AM–911/FG are components of Telegraph Terminal AN/FGC–29. Refer to TM 11–2265 for detailed information about components.

*c.* Forward all comments on this publication direct to: Commanding Officer, The Signal Corps Publications Agency, Fort Monmouth, N. J.

### 2. Forms and Records

*a. Unsatisfactory Equipment Reports.*

(1) Fill out and forward DA Form 468 (Unsatisfactory Equipment Report), to Commanding General, Signal Corps Engineering Laboratories, Fort Monmouth, N. J., as prescribed in AR 700–38.

(2) Fill out and forward DD Form 535 (Unsatisfactory Report), to Commander, Air Materiel Command, Wright-Patterson Air Force Base, Ohio, as prescribed in AF TO 00–35D–54.

*b. Damaged or Improper Shipment Report.* Fill out and forward DD Form 6, (Report of Damaged or Improper Shipment), as prescribed in AR 700–58 (Army); Navy Shipping Guide, Article 1850–4 (Navy); and AFR 71–4 (Air Force).

## Section II. DESCRIPTION AND DATA

### 3. Purpose and Use

Telegraph Terminal AN/FGC–29 is the terminal equipment for a 16-channel carrier telegraph system that provides communication over long range, twin-channel, single-sideband radio circuits operating in the high-frequency (hf) range.

*a.* The carrier telegraph channels are capable of teletypewriter operation at a maximum speed of 100 words per minute.

*b.* The center frequencies of the carrier telegraph channels are spaced 170 cycles apart, starting at 425 cycles per second (cps) and continuing up to 2,975 cps.

*c.* The telegraph channels use frequency-shift carrier signals, with a marking signal 42.5 cycles above center frequency and a spacing signal 42.5 cycles below the center frequency of each channel.

*d.* Diversity combining methods are used to overcome the effects of radio fading. Facilities are provided for both 2-channel and 4-channel diversity combining, using frequency diversity or space diversity, or both. Selection of 2-channel or 4-channel diversity combining can be made at Telegraph Terminal AN/FGC–29 or from a remote control location.

*e.* Multiplexing equipment is provided to derive two voice-frequency (vf) circuits from each of the radio channels. The radio bandwidth, from 200 to 6,000 cps, is divided into two transmission circuits, each with a bandwidth from 375 to 3,025 cps. Four such vf circuits are derived from the twin-channel radio and are used to transmit the carrier telegraph signals, or to provide telephone or facsimile service.

*f.* Equalizer and amplifier equipment is provided to permit operation of Telegraph Terminal AN/FGC–29 over line facilities to remotely located radio terminals.

### 4. Common Names

Common names, for the equipments covered in this manual, are listed in the chart below. They are used in text, in place of lengthy standard nomenclatures.

| Standard nomenclatures | Common names | Components |
|---|---|---|
| Telegraph Terminal AN/FGC–29 | AN/FGC–29 terminal | Cabinets 1 through 6. |
| Telegraph Terminal AN/FGT–2 | Transmitting terminal * | Cabinets 1 and 2. |
| Telegraph Terminal AN/FGR–3 | Receiving terminal * | Cabinets 3 through 6. |
| Multiplexer TD–97/FGT–2 | Multiplexer. | |
| Demultiplexer TD–98/FGR–3 | Demultiplexer. | |
| Audio Frequency Amplifier AM–911/FG | Audio frequency amplifier. | |

*Cabinet 2 of the transmitting terminal will be referred to as the *telegraph transmitter group;* cabinets 4 through 6 of the receiving terminal will be referred to as the *telegraph receiver group.*

## 5. System Application

(figs. 2 and 3)

*a. General.* In a typical application, two Telegraph Terminals AN/FGC–29 are used with an hf radio link to establish duplex telegraph communication between locations which may be thousands of miles apart.

(1) The AN/FGC–29 terminals are usually installed in communication centers located at various distances from the radio transmitter and receiver sites. Audio Frequency Amplifiers AM–911/FG, furnished with the AN/FGC–29 terminals, permit operation over interconnecting transmission lines of suitable characteristics. One audio frequency amplifier contains equalizing and amplifying facilities for two separate line circuits.

(2) Four 2-way vf circuits are derived from the twin-channel radio equipment by Multiplexers TD–97/FGT–2 and Demultiplexers TD–98/FGR–3, which form a part of the AN/FGC–29 terminals.

*b. Transmission Lines.* The method of operation over the interconnecting lines between the AN/FGC–29 terminal and the radio transmitter and receiver terminals depends on the distances between these locations and the type of line facilities available. Common types of line facilities and permissible lengths are listed in paragraph 15*c* and *d*.

(1) *Six-kc facilities.* When nonloaded cable lines are used between the AN/FGC–29 terminal and the radio terminals, the audio frequency amplifiers are used to compensate for the line attenuation characteristics over a frequency range from 300 cps to 6,000 cps. These lines are considered as 6-kilocycle (kc) facilities and are used to extend the 6-kc radio channels to the location of the AN/FGC–29 terminal.

(2) *Three-kc facilities.* Three-kc facilities may consist of loaded cable lines or the channels of a radio relay or carrier telephone systems. When loaded cable lines are used between the AN/FGC–29 terminal and the radio terminals, the audio frequency amplifiers are used for line equalization over a frequency range from 300 cps to 3,500 cps. The multiplexers and demultiplexers are then located at the radio terminals to divide each of the 6-kc radio channels into two 3-kc circuits. These circuits are extended over the 3-kc facilities to the location of the AN/FGC–29 terminal.

*c. Frequency Diversity.* Figure 2 shows a typical system application in which two AN/FGC–29 terminals operate over a radio circuit using frequency diversity to reduce the effects of selective fading.

(1) At the west terminal of the system, the AN/FGC–29 terminal is connected to the radio transmitter by a 15-mile cable and to the radio receiver by a 20-mile cable. Two nonloaded 19-gage pairs in each cable are used as 6-kc line facilities between the AN/FGC–29 terminal and the radio terminals. One audio frequency amplifier is located at the radio transmitter and compensates for the attenuation characteristics of both transmitting cable pairs. A second audio frequency amplifier is located at the AN/FGC–29 terminal and compensates for the attenuation characteristics of both receiving cable pairs.

(2) At the east terminal of the system, the interconnecting cables are 30 and 35 miles long and are used as 3-kc facilities.

Loaded 19-gage pairs in each cable connect the AN/FGC–29 terminal with the radio terminals. In this application, two multiplexers are required at the radio transmitter and two demultiplexers are required at the radio receiver. Two audio frequency amplifiers are located at the radio transmitter to equalize the three transmitting cable pairs. Two more are required for the four receiving cable pairs.

(3) The radio equipment provides two channels of communication, each with a bandwidth of approximately 6 kc, designated as sideband A and sideband B. Four vf circuits, each with a bandwidth of approximately 3 kc, are derived from the radio channels by the multiplexers and demultiplexers. In a frequency diversity system, any two of these four vf circuits may be used to transmit the carrier telegraph signals and the remaining two are available for telephone or facsimile transmission.

(4) The signal path through the system for the west to east direction of transmission is traced as follows: at the west terminal, the transmitting telegraph loops carry direct current (dc) telegraph impulses from the associated teletypewriter equipment to the telegraph transmitter group. Here the input telegraph signals control the frequencies of 16 carrier telegraph channels. The output carrier signals of the telegraph transmitter group are applied to the two input circuits of one multiplexer. Signals from telephone and facsimile circuits are applied to the two input circuits of a second multiplexer. The output signals of both multiplexers are transmitted over a 15-mile cable to the radio transmitter site where an audio frequency amplifier compensates for the line loss and applies the signals to the input circuits of the radio transmitter. At the distant (east) terminal of the system, incoming signals pass from the output circuits of the radio receiver to the input circuits of two demultiplexers, located at the radio receiver site. The output signals for the demultiplexers are then transmitted over a 30-mile cable to two audio frequency amplifiers, which compensate for the line loss. The received carrier telegraph signals appear at both output circuits of one audio frequency amplifier and are applied to two separate input circuits of the telegraph receiver group, which are designated as the A path and the B path. For each telegraph channel, signals from the A path are combined with those from the B path and are then converted into dc telegraph impulses. The output telegraph signals are carried by the receiving telegraph loops to the associated teletypewriter equipment. The received telephone and facsimile signals appear at the output circuits of the second audio frequency amplifier and are applied to telephone and facsimile circuits.

(5) The signal path through the system of the east to west direction of transmission is traced as follows: at the east terminal, dc telegraph impulses from the transmitting telegraph loops control the frequencies of 16 carrier telegraph channels in the telegraph transmitter group. The output carrier signals of the telegraph transmitter group and the signals from telephone and facsimile circuits are transmitted over a 35-mile cable to the radio transmitter site where two audio frequency amplifiers compensate for the line loss. The output carrier telegraph signals of one audio frequency amplifier are applied to the two input circuits of one multiplexer. The output telephone and facsimile signals of the second audio frequency amplifier are applied to the two input circuits of the second multiplexer. The output signals of both multiplexers are then applied to the input circuits of the radio transmitter. At the distant (west) terminal of the system, incoming signals from the output circuits of the radio receiver are transmitted over a 20-mile cable to an audio frequency amplifier. The audio frequency amplifier compensates for the line attenuation and feeds the signals to two demultiplexers. The received carrier telgraph signals appear at both output circuits of one demultiplexer and are applied to the A path and the B path of the telegraph receiver group. Signals

from the A path are combined with those from the B path and are then converted into dc telegraph impulses for the receiving telegraph loops. The received telephone and facsimile signals appear at the output circuits of the second demultiplexer and are applied to telephone and facsimile circuits.

*Figure 2. Telegraph Terminal AN/FGC–29, typical system application using frequency diversity.*

(Contained in separate envelope)

*d. Space Diversity.* Figure 3 shows a typical system application in which two AN/FGC–29 terminals are operated over a radio circuit using space diversity to overcome the effects of fading. Space diversity is obtained by using two radio receivers at each end of the system.

(1) At the west terminal of the system, nonloaded 19-gage cable pairs between the AN/FGC–29 terminal and the radio terminals are used as 6-kc facilities. One audio frequency amplifier is located at the radio transmitter and compensates for the attenuation characteristics of the two transmitting cable pairs. Two more audio frequency amplifiers are required for the three receiving cable pairs.

(2) At the east terminal of the system, loaded 19-gage pairs in the interconnecting cables are used as 3-kc facilities. In this application, two multiplexers are located at the radio transmitter and three demultiplexers at the radio receivers. Two audio frequency amplifiers are located at the radio transmitter for the three transmitting cable pairs, and two more are used for the four receiving pairs.

(3) Four vf circuits are derived from the radio channels by the multiplexers associated with the radio transmitter and the demultiplexers associated with radio receiver No. 1. In a space diversity system, any one of these vf circuits may be used to transmit the carrier telegraph signals. Radio receiver No. 2 and its associated demultiplexer provide a second source of the received signals.

(4) The signal path through the system for the west to east direction of transmission is traced as follows: at the west terminal, the transmitting telegraph loops carry dc telegraph impulses from the associated teletypewriter equipment to the telegraph transmitter group. Here the input telegraph signals control the frequencies of 16 carrier telegraph channels. The output carrier signals of the telegraph transmitter group are applied to an input circuit of one multiplexer. Signals from telephone and facsimile circuits are applied to the two input circuits of a second multiplexer. The output signals from both multiplexers are then transmitted over a 15-mile cable to the radio transmitter site where an audio frequency amplifier compensates for the line attenuation and applied the signals to the input circuits of the radio transmitter. At the distant (east) terminal of the system, incoming signals pass from radio receiver No. 1 to the input circuits of two demultiplexers and from radio receiver No. 2 to the input circuit of a third demultiplexer located at the radio receiver site. The output signals from all three demultiplexers are then transmitted over a 30-mile cable to two audio frequency amplifiers which compensate for the line loss. The received carrier telegraph signals appear at both output circuits of one audio frequency amplifier and are applied to the A path and B path circuits of the telegraph receiver group. For each telegraph channel, the signals from the A path are combined with those from the B path, and are then converted into dc telegraph impulses. The output telegraph signals are carried by the receiving telegraph loops to the associated teletypewriter equipment. The received telephone and facsimile signals appear at the output circuits of the second audio frequency amplifier and are applied to telephone and facsimile circuits.

(5) The signal path through the system for the east to west direction of transmission is traced as follows: at the east terminal, dc telegraph impulses from the transmitting telegraph loops control the frequencies of 16 carrier telegraph channels in the telegraph transmitter group. The output carrier signals of the telegraph transmitter group and the signals from telephone and facsimile circuits are transmitted over a 35-mile cable to the

radio transmitter site where two audio frequency amplifiers compensate for the line loss. The output carrier telegraph signals of one audio frequency amplifier are applied to an input circuit of one multiplexer. The output telephone and facsimile signals of the second audio frequency amplifier are applied to the two input circuits of the second multiplexer. The output signals of both multiplexers are then applied to the input circuits of the radio transmitter. At the distant (west) terminal of the system, incoming signals from the output circuits of radio receiver No. 1 and radio receiver No. 2 are transmitted over a 20-mile cable to two audio frequency amplifiers. The audio frequency amplifiers compensate for the line attenuation and feed the signals to three demultiplexers. The received carrier telegraph signals appear at the output circuits of two different demultiplexers and are applied to the A path and B path of the telegraph receiver group. Signals from the A path are combined with those from the B path and are then converted into dc telegraph impulses for the receiving telegraph loops. The received telephone and facsimile signals appear at the output circuits of a third demultiplexer and pass to telephone and facsimile circuits.

*Figure 3. Telegraph Terminal AN/FGC–29, typical system application using space diversity.*

(Contained in separate envelope)

*e. Diversity Combining.* The AN/FGC–29 terminal is provided with means for either 2-channel or 4-channel diversity combining. Either method may be used with a frequency diversity system (fig. 2) or a space diversity system (fig. 3).

(1) *Two-channel diversity.* Two-channel diversity is obtained when each of the 16 transmitting telegraph loops controls the frequency of a different carrier channel in the telegraph transmitter group. The output signals are transmitted by radio over two different frequency diversity or space diversity paths to the receiving end of the system where they are applied to the A path and B path of the telegraph receiver group. For each of the carrier channels, signals from the A and B paths are combined and are then converted into telegraph signals for each of the 16 receiving telegraph loops.

(2) *Four-channel diversity.* Under adverse fading conditions, operational improvement is obtained by using 4-channel diversity. Four-channel diversity is obtained when one transmitting telegraph loop controls the frequencies of two carrier channels in the telegraph transmitter group simultaneously. Both output signals are transmitted by radio over two different frequency diversity or space diversity paths to provide a total of four received signals. Two of these enter the A path and the other two enter the B path of the telegraph receiver group. Here the four incoming signals are combined and are then converted into telegraph signals for one receiving telegraph loop. When 4-channel diversity is used throughout the terminal, the capacity of the system is reduced to eight channels.

## 6. Technical Characteristics of Telegraph Terminal AN/FGC–29

(fig. 1)

| | |
|---|---|
| Telegraph channels: | |
| Number | 16. |
| Maximum word speed | 100 wpm. |
| Maximum dot frequency | 37 cps. |
| Channel center frequencies | 425 to 2,975 cps. |
| Channel spacing | 170 cps. |
| Type of modulation | Frequency-shift. |
| Frequency deviation | ±42.5 cps. |
| Diversity options | Frequency or space. |
| Diversity combining options | 2-channel or 4-channel. |
| Telegraph loops: | |
| Number | 16. |
| Type of signals | Neutral. |
| Loop current | 20 ma or 60 ma. |
| Maximum loop resistance | 1,000 ohms. |
| Loop battery options: | |
| Transmitting loops: | |
| Battery from equipment | −130 v dc. |
| Battery from loops | ±130 v dc. |
| Receiving loops: | |
| Battery from equipment | −130 v dc. |
| Voice-frequency channels: | |
| Number | 4. |
| Bandwidth, each | 375 to 3,025 cps. |
| Impedance: | |
| Output, transmitting terminal | 600 ohms. |
| Input, receiving terminal | 600 ohms. |

Size ..... 11 ft 3 in. long x 6 ft 3 in. high x 2 ft deep.
Weight ..... 5,000 lb.
Number of cabinets ..... 6.
Power requirements:
  Voltage ..... 107 to 122 or 210 to 250 v ac.
  Frequency ..... 50 or 60 cps.
  Power consumption ..... 4,000 watts.
Transmission medium:
  Type ..... Single-sideband radio.
  Frequency range ..... Hf (3 to 30 mc).
  Number of channels ..... 2.
  Bandwidth, each channel ..... 200 to 6,000 cps.
  Facilities to radio sites ..... 3-kc or 6-kc lines.

## 7. Technical Characteristics of Transmitter
(figs. 5 and 44)

Number per AN/FGC–29 terminal ..... 8.
Transmission circuits:
  Input:
    Number ..... 2.
    Type of signals ..... Neutral telegraph.
  Output:
    Number ..... 2.
    Impedance, each ..... 600 ohms.
    Type of signals ..... Frequency-shift carrier.
  Output carrier frequencies:

| Transmitter channels | Channel No. | Spacing (cps) | Center (cps) | Marking (cps) |
|---|---|---|---|---|
| 1 & 2 | 1 | 1, 742. 5 | 1, 785 | 1, 827. 5 |
| | 2 | 2, 932. 5 | 2, 975 | 3, 017. 5 |
| 3 & 4 | 3 | 1, 912. 5 | 1, 955 | 1, 997. 5 |
| | 4 | 2, 762. 5 | 2, 805 | 2, 847. 5 |
| 5 & 6 | 5 | 2, 082. 5 | 2, 125 | 2, 167. 5 |
| | 6 | 2, 592. 5 | 2, 635 | 2, 677. 5 |
| 7 & 8 | 7 | 2, 252. 5 | 2, 295 | 2, 337. 5 |
| | 8 | 2, 422. 5 | 2, 465 | 2, 507. 5 |
| 9 & 10 | 9 | 2, 422. 5 | 2, 465 | 2, 507. 5 |
| | 10 | 2, 252. 5 | 2, 295 | 2, 337. 5 |
| 11 & 12 | 11 | 2, 592. 5 | 2, 635 | 2, 677. 5 |
| | 12 | 2, 082. 5 | 2, 125 | 2, 167. 5 |
| 13 & 14 | 13 | 2, 762. 5 | 2, 805 | 2, 847. 5 |
| | 14 | 1, 912. 5 | 1, 955 | 1, 997. 5 |
| 15 & 16 | 15 | 2, 932. 5 | 2, 975 | 3, 017. 5 |
| | 16 | 1, 742. 5 | 1, 785 | 1, 827. 5 |

Output levels:
  Normal (per channel) ..... −15 dbm.
  Maximum (per channel) ..... −10 dbm.

Power requirements:
  Loop battery supply:
    Voltage ..... −130 v dc.
    Power consumption ..... 16 watts.
  B-plus supply:
    Voltage ..... +200 v dc.
    Power consumption ..... 1.5 watts.
  Ac power supply:
    Voltage ..... 230 v ac, regulated.
    Frequency ..... 50 or 60 cps.
    Power consumption ..... 26 watts.

## 8. Technical Characteristics of SUBGROUP MODULATOR
(figs. 5 and 47)

Number per AN/FGC–29 terminal ..... 1.
Transmission circuits:
  Input:
    Number ..... 2.
    Impedance, each ..... 600 ohms.
  Output:
    Number ..... 1.
    Impedance ..... 600 ohms.
Input carrier frequencies:
  Direct path:

| Channel No. | Spacing (cps) | Center (cps) | Marking (cps) |
|---|---|---|---|
| 1 | 1, 742. 5 | 1, 785 | 1, 827. 5 |
| 3 | 1, 912. 5 | 1, 955 | 1, 997. 5 |
| 5 | 2, 082. 5 | 2, 125 | 2, 167. 5 |
| 7 | 2, 252. 5 | 2, 295 | 2, 337. 5 |
| 9 | 2, 422. 5 | 2, 465 | 2, 507. 5 |
| 11 | 2, 592. 5 | 2, 635 | 2, 677. 5 |
| 13 | 2, 762. 5 | 2, 805 | 2, 847. 5 |
| 15 | 2, 932. 5 | 2, 975 | 3, 017. 5 |

  Translated path:

| Channel No. | Spacing (cps) | Center (cps) | Marking (cps) |
|---|---|---|---|
| 2 | 2, 932. 5 | 2, 975 | 3, 017. 5 |
| 4 | 2, 762. 5 | 2, 805 | 2, 847. 5 |
| 6 | 2, 592. 5 | 2, 635 | 2, 677. 5 |
| 8 | 2, 422. 5 | 2, 465 | 2, 507. 5 |
| 10 | 2, 252. 5 | 2, 295 | 2, 337. 5 |
| 12 | 2, 082. 5 | 2, 125 | 2, 167. 5 |
| 14 | 1, 912. 5 | 1, 955 | 1, 955. 5 |
| 16 | 1, 742. 5 | 1, 785 | 1, 827. 5 |

Output carrier frequencies:

| Channel No. | Spacing (cps) | Center (cps) | Marking (cps) |
|---|---|---|---|
| 1 | 1, 742. 5 | 1, 785 | 1, 827. 5 |
| 2 | 467. 5 | 425 | 382. 5 |
| 3 | 1, 912. 5 | 1, 955 | 1, 997. 5 |
| 4 | 637. 5 | 595 | 552. 5 |
| 5 | 2, 082. 5 | 2, 125 | 2, 167. 5 |
| 6 | 807. 5 | 765 | 722. 5 |
| 7 | 2, 252. 5 | 2, 295 | 2, 337. 5 |
| 8 | 977. 5 | 935 | 892. 5 |
| 9 | 2, 422. 5 | 2, 465 | 2, 507. 5 |
| 10 | 1, 147. 5 | 1, 105 | 1, 062. 5 |
| 11 | 2, 592. 5 | 2, 635 | 2, 677. 5 |
| 12 | 1, 317. 5 | 1, 275 | 1, 232. 5 |
| 13 | 2, 762. 5 | 2, 805 | 2, 847. 5 |
| 14 | 1, 487. 5 | 1, 445 | 1, 402. 5 |
| 15 | 2, 932. 5 | 2, 975 | 3, 017. 5 |
| 16 | 1, 657. 5 | 1, 615 | 1, 572. 5 |

Input levels:
- Normal (per channel) — −15 dbm.
- Maximum (per channel) — −12 dbm.

Transmission loss — 30 db.

Output levels:
- Normal (per channel) — −45 dbm.
- Maximum (per channel) — −42 dbm.

Power requirements:
- Voltage — 230 v ac, regulated.
- Frequency — 50 or 60 cps.
- Power consumption — 47 watts.

## 9. Technical Characteristics of LEVEL CONTROL & PLATE SUPPLY

(figs. 5 and 49)

Number per AN/FGC–29 terminal — 1.

Transmission circuit:
- Gain — 0 to 50 db in 1-db steps.
- Type of signals — Frequency-shift carrier.
- Number of channels — 16.
- Input and output impedance — 600 ohms.
- Normal input level (per channel) — −45 dbm.
- Normal output level (per channel):
  - Space diversity — −10 dbm.
  - Frequency diversity — −4 dbm.
- Maximum output level (per channel) — 0 dbm.

Plate supply circuits:
- Number — 2.
- Output voltage — +200 v dc.
- Normal load, each — 6 watts.
- Capacity, each — 15 watts.

Power requirements:
- Voltage — 230 v ac, regulated.
- Frequency — 50 or 60 cps.
- Power consumption — 63 watts.

## 10. Technical Characteristics of SUBGROUP DEMODULATOR

(figs. 5 and 51)

Number per AN/FGC–29 terminal — 2.

Transmission circuits:
- Input:
  - Number — 1.
  - Impedance — 600 ohms.
- Output:
  - Number — 2.
  - Impedance, each — 600 ohms.

Input carrier frequencies:

| Channel No. | Spacing (cps) | Center (cps) | Marking (cps) |
|---|---|---|---|
| 1 | 1, 742. 5 | 1, 785 | 1, 827. 5 |
| 2 | 467. 5 | 425 | 382. 5 |
| 3 | 1, 912. 5 | 1, 955 | 1, 997. 5 |
| 4 | 637. 5 | 595 | 552. 5 |
| 5 | 2, 082. 5 | 2, 125 | 2, 167. 5 |
| 6 | 807. 5 | 765 | 722. 5 |
| 7 | 2, 252. 5 | 2, 295 | 2, 337. 5 |
| 8 | 977. 5 | 935 | 892. 5 |
| 9 | 2, 422. 5 | 2, 465 | 2, 507. 5 |
| 10 | 1, 147. 5 | 1, 105 | 1, 062. 5 |
| 11 | 2, 592. 5 | 2, 635 | 2, 677. 5 |
| 12 | 1, 317. 5 | 1, 275 | 1, 232. 5 |
| 13 | 2, 762. 5 | 2, 805 | 2, 847. 5 |
| 14 | 1, 487. 5 | 1, 445 | 1, 402. 5 |
| 15 | 2, 932. 5 | 2, 975 | 3, 017. 5 |
| 16 | 1, 657. 5 | 1, 615 | 1, 572. 5 |

Output carrier frequencies:

Direct path:

| Channel No. | Spacing (cps) | Center (cps) | Marking (cps) |
|---|---|---|---|
| 1 | 1, 742. 5 | 1, 785 | 1, 827. 5 |
| 3 | 1, 912. 5 | 1, 955 | 1, 997. 5 |
| 5 | 2, 082. 5 | 2, 125 | 2, 167. 5 |
| 7 | 2, 252. 5 | 2, 295 | 2, 337. 5 |
| 9 | 2, 422. 5 | 2, 465 | 2, 507. 5 |
| 11 | 2, 592. 5 | 2, 635 | 2, 677. 5 |
| 13 | 2, 762. 5 | 2, 805 | 2, 847. 5 |
| 15 | 2, 932. 5 | 2, 975 | 3, 017. 5 |

Translated path:

| Channel No. | Spacing (cps) | Center (cps) | Marking (cps) |
|---|---|---|---|
| 2 | 2, 932. 5 | 2, 975 | 3, 017. 5 |
| 4 | 2, 762. 5 | 2, 805 | 2, 847. 5 |
| 6 | 2, 592. 5 | 2, 635 | 2, 677. 5 |
| 8 | 2, 427. 5 | 2, 465 | 2, 507. 5 |
| 10 | 2, 252. 5 | 2, 295 | 2, 337. 5 |
| 12 | 2, 082. 5 | 2, 125 | 2, 167. 5 |
| 14 | 1, 912. 5 | 1, 955 | 1, 997. 5 |
| 16 | 1, 742. 5 | 1, 785 | 1, 827. 5 |

Input levels:
- Normal (per channel) ..... 0 dbm.
- Maximum (per channel) ..... +3 dbm.

Transmission loss ..... 8 db.

Output levels:
- Normal (per channel) ..... −8 dbm.
- Maximum (per channel) ..... −5 dbm.

Power requirements:
- Voltage ..... 230 v ac, regulated.
- Frequency ..... 50 or 60 cps.
- Power consumption ..... 61 watts.

## 11. Technical Characteristics of Receiver (fig. 7, 8, and 53)

Number per AN/FGC–29 terminal ..... 16.

Power requirements:
- Voltage ..... 230 v ac, regulated.
- Frequency ..... 50 or 60 cps.
- Power consumption ..... 50 watts.

Transmission circuits ..... Two (identical), each with characteristics listed below.

Impedance:
- Input ..... 600 ohms.
- Output ..... 50,000 ohms.

Input and output carrier frequencies:

| RECEIVER CHANNEL | Spacing (cps) | Center (cps) | Marking (cps) |
|---|---|---|---|
| 1 | 1, 742. 5 | 1, 785 | 1, 827. 5 |
| 2 | 2, 932. 5 | 2, 975 | 3, 017. 5 |
| 3 | 1, 912. 5 | 1, 955 | 1, 997. 5 |
| 4 | 2, 762. 5 | 2, 805 | 2, 847. 5 |
| 5 | 2, 082. 5 | 2, 125 | 2, 167. 5 |
| 6 | 2, 592. 5 | 2, 635 | 2, 677. 5 |
| 7 | 2, 252. 5 | 2, 295 | 2, 337. 5 |
| 8 | 2, 422. 5 | 2, 465 | 2, 507. 5 |
| 9 | 2, 422. 5 | 2, 465 | 2, 507. 5 |
| 10 | 2, 252. 5 | 2, 295 | 2, 337. 5 |
| 11 | 2, 592. 5 | 2, 635 | 2, 677. 5 |
| 12 | 2, 082. 5 | 2, 125 | 2, 167. 5 |
| 13 | 2, 762. 5 | 2, 805 | 2, 847. 5 |
| 14 | 1, 912. 5 | 1, 955 | 1, 997. 5 |
| 15 | 2, 932. 5 | 2, 975 | 3, 017. 5 |
| 16 | 1, 742. 5 | 1, 785 | 1, 827. 5 |

Input levels:
- Normal ..... −8 dbm.
- Maximum ..... −5 dbm.
- Minimum ..... −50 dbm.

Normal output voltage ..... 9 v.

## 12. Technical Characteristics of Combiner figs. 7, 8, and 56

Number per AN/FGC–29 terminal ..... 8.

Transmission circuits:

Input:
- Number ..... 4.
- Impedance, each ..... 500,000 ohms.
- Type of signals ..... Frequency-shift carrier.

Transmission circuits—Continued

Output:
- Number ..... 2.
- Type of signals ..... Neutral telegraph.

Input quarter frequencies:

| COMBINER CHANNELS | Channel No. | Spacing (cps) | Center (cps) | Marking (cps) |
|---|---|---|---|---|
| 1 & 2 | 1 | 1, 742. 5 | 1, 785 | 1, 827. 5 |
| | 2 | 2, 932. 5 | 2, 975 | 3, 017. 5 |
| 3 & 4 | 3 | 1, 912. 5 | 1, 955 | 1, 997. 5 |
| | 4 | 2, 762. 5 | 2, 805 | 2, 847. 5 |
| 5 & 6 | 5 | 2, 082. 5 | 2, 125 | 2, 167. 5 |
| | 6 | 2, 592. 5 | 2, 635 | 2, 677. 5 |
| 7 & 8 | 7 | 2, 252. 5 | 2, 295 | 2, 337. 5 |
| | 8 | 2, 422. 5 | 2, 465 | 2, 507. 5 |
| 9 & 10 | 9 | 2, 422. 5 | 2, 465 | 2, 507. 5 |
| | 10 | 2, 252. 5 | 2, 295 | 2, 337. 5 |
| 11 & 12 | 11 | 2, 592. 5 | 2, 635 | 2, 677. 5 |
| | 12 | 2, 082. 5 | 2, 125 | 2, 167. 5 |
| 13 & 14 | 13 | 2, 762. 5 | 2, 805 | 2, 857. 5 |
| | 14 | 1, 912. 5 | 1, 955 | 1, 997. 5 |
| 15 & 16 | 15 | 2, 932. 5 | 2, 975 | 3, 017. 5 |
| | 16 | 1, 742. 5 | 1, 785 | 1, 827. 5 |

Normal input voltage ..... 9 v.

Power requirements:

Loop battery supply:
- Voltage ..... −130 v dc.
- Power consumption ..... 16 watts.

B-plus supply:
- Voltage ..... +200 v dc.
- Power consumption ..... 25 watts.

Ac power supply:
- Voltage ..... 230 v ac, grounded.
- Frequency ..... 50 or 60 cps.
- Power consumption ..... 54 watts.

## 13. Technical Characteristics of Multiplexer TD–97/FGT–2 (figs. 4 and 58)

Number per AN/FGC–2 terminal ..... 2.

Transmission circuits:

Input:
- Number ..... 2.
- Impedance, each ..... 600 ohms.
- Bandwidth, each ..... 375 to 3,025 cps.

Output:
- Number ..... 1.
- Impedance ..... 600 ohms.
- Bandwidth ..... 375 to 5,915 cps.

Normal operating levels:

Input:
- Telephone (referred to 0-db level point) ..... −4 db.
- Facsimile ..... 0 dbm.
- Carrier telegraph (per channel) ..... −10 dbm.

Normal operating levels—Continued
- Output:
  - Telephone (referred to 0-db level point): −4 db.
  - Facsimile: 0 dbm.
  - Carrier telegraph (per channel): −10 dbm.

Maximum permissible levels:
- Input:
  - Single frequency: +13 dbm.
  - Carrier telegraph (per channel): −9 dbm.
- Output:
  - Single frequency: +22 dbm.
  - Carrier telegraph (per channel): −3 dbm.

Gain: 24 db max, in 1-db steps.

Power requirements:
- Voltage: 115 or 230 v ac.
- Frequency: 50 or 60 cps.
- Power consumption: 47 watts.

## 14. Technical Characteristics of Demultiplexer TD–98/FGR–3

(figs. 6 and 63)

Number per AN/FGC–29 terminal: 3.

Transmission circuits:
- Input:
  - Number: 1.
  - Impedance: 600 ohms.
  - Bandwidth: 375 to 5,915 cps.
- Output:
  - Number: 2.
  - Impedance, each: 600 ohms.
  - Bandwidth, each: 375 to 3,025 cps.

Normal operating levels:
- Input:
  - Telephone (referred to 0-db level point): −9 db.
  - Facsimile: −5 dbm.
  - Carrier telegraph (per channel): −15 dbm.
- Output:
  - Telephone (referred to 0-db level point): +1 db.
  - Facsimile: 0 dbm.
  - Carrier telegraph (per channel): 0 dbm.

Maximum permissible levels:
- Input:
  - Single frequency: +13 dbm.
  - Carrier telegraph (per channel): −9 dbm.
- Output:
  - Single frequency: +22 dbm.
  - Carrier telegraph (per channel): 0 dbm.

*Note.* An input level control is provided to reduce the incoming signal level when it exceeds the correct input level for the demultiplexer.

Gain: 24 db max in 1-db steps.

Power requirements:
- Voltage: 115 or 230 v ac.
- Frequency: 50 or 60 cps.
- Power consumption: 60 watts.

## 15. Technical Characteristics of Audio Frequency Amplifier AM–911/FG

(figs. 1, 4, and 61)

Number per AN/FGC–29 terminal: 4.

Power requirements:
- Voltage: 115 or 230 v ac.
- Frequency: 50 or 60 cps.
- Power consumption: 43 watts.

Transmission circuits: Two (identical), each with characteristics listed below.

Equalizer switch in NON-LOADED CABLE position:
- Equalized bandwidth: 300 to 6,000 cps.
- Maximum line lengths for equalization of ±1 db:

Nonloaded cables:

| Gage | Type | Capacitance (μf per mi) | Length (mi) |
|---|---|---|---|
| 16 | Quadded | 0.062 | 33 |
| 19 | Quadded | .062 | 20 |
| 19 | Nonquadded | .084 | 15 |
| 22 | Nonquadded | .082 | 10 |
| 24 | Nonquadded | .072 | 8 |
| 26 | Nonquadded | .069 | 6 |
| | Cable assembly CX–1065/G | | 17 |

Open wire lines:

| Type | | | Length (mi) |
|---|---|---|---|
| 104 | 40% | C–S | 75 |
| 128 | 40% | C–S | 100 |
| 104 | 30% | C–S | 55 |
| 128 | 30% | C–S | 75 |

Equalizer switch in LOADED CABLE position:
- Equalized bandwidth: 300 to 3,500 cps.
- Maximum line lengths for equalization of ± 1 db:

Loaded cables

| Gage | Type | Capacitance (μf per mi) | Loading | Length (mi) |
|---|---|---|---|---|
| 16 | Quadded | 0.062 | H–44 | 95 |
| 16 | Quadded | .062 | H–88 | 60 |
| 19 | Quadded | .062 | H–44 | 50 |
| 19 | Quadded | .062 | H–88 | 57 |
| 19 | Nonquadded | .084 | H–44 | 40 |
| 22 | Nonquadded | .082 | H–44 | 23 |
| 24 | Nonquadded | .072 | H–44 | 16 |

Equalizer switch in EQUAL OUT position:

| | |
|---|---|
| Bandwidth | 300 to 6,000 cps. |
| Gain | 0 to 50 db in 1-db steps. |

Impedance:

| | |
|---|---|
| Input | 150, 600, or 1,350 ohms. |
| Output | 600 ohms. |

Maximum power output:

| | |
|---|---|
| Single frequency | +22 dbm. |
| Carrier telegraph (per channel) | −3 dbm. |

## 16. Major Components

(fig. 1)

| Component (nomenclature) | Cabinet No. | Required No. | Height (in.) | Length (in.) | Depth (in.) | Unit weight (lb) |
|---|---|---|---|---|---|---|
| AN/FGT–2 | 1 | 1 | 75 | 22½ | 24 | 662 |
| | 2 | 1 | 75 | 22½ | 24 | 809 |
| AN/FGR–3 | 3 | 1 | 75 | 22½ | 24 | 749 |
| | 4 | 1 | 75 | 22½ | 24 | 869 |
| | 5 | 1 | 75 | 22½ | 24 | 900 |
| | 6 | 1 | 75 | 22½ | 24 | 874 |

## 17. Minor Components

| Component | Required No. | Height (in.) | Length (in.) | Depth (in.) | Unit weight (lb.) |
|---|---|---|---|---|---|
| Transformer Assembly TF–206/FG | 1 | 3½ | 19 | 4⅞ | 10 |
| RELAY PANEL | 1 | 7 | 19 | 10$^{3}/_{16}$ | 33 |
| DUMMY CIRCUIT PANEL | 7 | 7 | 19 | 4 | 3$^{13}/_{16}$ |
| Electrical Headset H–110/G | 2 | | | | 1½ |
| Power cord | 9 | | 48 | | $^{11}/_{16}$ |
| Cable assembly | 9 | | 48 | | 1¼ |
| Intercabinet signal cable assembly | 7 | | 24 | | 1 |
| Switchboard patching cord (single plug each end) | 2 | | 72 | | $^{7}/_{16}$ |
| Switchboard patching cord (twin plugs both ends) | 2 | | 24 | | $^{7}/_{16}$ |
| Switchboard patching cord (twin plugs both ends) | 2 | | 48 | | $^{7}/_{16}$ |
| Switchboard patching cord (twin plugs both ends) | 8 | | 72 | | $^{7}/_{16}$ |
| Switchboard patching cord (twin plugs both ends) | 4 | | 96 | | $^{7}/_{16}$ |
| Running spares (par. 35) | 1 set | | | | 41 |

## 18. Description of Telegraph Terminal AN/FGC–29

(fig. 1)

*a. General.* The AN/FGC–29 terminal consists of six steel cabinets which occupy a space 11 feet 3 inches long, 2 feet deep, and 6 feet 3 inches high. The cabinets are numbered from left to right (viewed from the front). The transmitting terminal is contained in cabinets 1 and 2 and the receiving terminal, in cabinets 3 through 6. Signal connections between cabinets are made with flexible cables, equipped with multicontact connectors. Connections to the equipment are made at terminal boards with screw-type terminals. The transmitting terminal is completely independent of the receiving terminal and they may be separated, if necessary.

*b. Cabinets.* The cabinets of the AN/FGC–29 terminal are physically identical except for component differences and wiring arrangements. The cabinets are of sheet steel construction, 22½ inches long, 24 inches deep, and 75 inches high. Each cabinet is provided with power wiring ducts, signal wiring ducts, and facilities for mounting various components. A door that is equipped with an air filter is provided at the rear of each cabinet. An internal blower provides pressurized ventilation by drawing filtered air into the bottom of the cabinet and forcing it out through ventilators at the top. Air ducts are provided for directing the ventilating air. Descriptions of the individual cabinets are given in paragraphs 19 through 24.

*c. Drawer-Type Chassis.* Most of the components mounted in cabinets are drawer-type chassis having in common certain physical characteristics which are described in (1) through (5) below. Additional information for individual components is given in paragraphs 26 through 34.

(1) Each drawer-type chassis is 16 inches square, with a front panel 19 inches long and either 5¼ or 7 inches high.

(2) Signal and power wiring is brought to connectors at the rear of the chassis by means of the cable assembly and power cord installed in the cabinet.

(3) The chassis is mounted in the cabinet by means of drawer slides, which permit the

component to be withdrawn for inspection and maintenance. The drawer is withdrawn from the cabinet by releasing four captive screws on the front panel and then pulling forward on the handles. The drawer is rolled out on its slides without disturbing the power or signal connections and without interrupting service.

(4) Controls used during routine operation are located on the front panel. They consist of switches, jacks, level controls, variable resistors, indicator lamps, and fuses. Controls needed only for alignment are located inside the chassis.

(5) Separate subassemblies are mounted on the framework of the chassis. Cabling interconnects the subassemblies, the circuit elements located on the front panel, and the power and signal connectors. The subassemblies are not plug-in items, but they can be removed for maintenance by an experienced repairman. Identical subassemblies are used for different circuit applications in different components.

## 19. Description of Cabinet 1

(fig. 4)

Cabinet 1 contains multiplexing, amplifying, and testing facilities for the transmitting terminal. The components of cabinet 1 are listed in the chart below.

| Quantity | Unit |
|---|---|
| 2 | Audio Frequency Amplifier AM–911/FG. |
| 1 | TRANSMITTER METER PANEL. |
| 1 | 3KC SEND BAND TEST PANEL. |
| 2 | Multiplexer TD–97/FGT–2. |
| 2 | Storage drawer. |
| 1 | LOOP BATTERY PANEL. |
| 1 | Transformer Assembly TF–206/FG (fig. 162). |
| 1 | Main power unit (fig. 162). |
| 2 | Loop battery supply (fig. 170). |

*Note.* In some system applications of the AN/FGC–29 terminal, the audio frequency amplifiers or the multiplexers, or both, are replaced by dummy circuit panels (par. 25).

## 20. Description of Cabinet 2

(fig. 5)

Cabinet 2 contains the telegraph transmitter group that converts dc telegraph impulses into outgoing carrier signals for 16 carrier telegraph channels. The components of cabinet 2 are listed in the chart below.

| Quantity | Unit |
|---|---|
| 1 | AC POWER SWITCHING PANEL. |
| 1 | LEVEL CONTROL & PLATE SUPPLY. |
| 1 | SUBGROUP MODULATOR. |
| 8 | Transmitter. |
| 1 | Voltage regulator (fig. 168). |

## 21. Description of Cabinet 3

(fig. 6)

Cabinet 3 contains amplifying, demultiplexing, and testing facilities for the receiving terminal. The components of cabinet 3 are listed in the chart below.

| Quanitiy | Unit |
|---|---|
| 2 | Audio Frequency Amplifier AM–911/FG. |
| 1 | DIVERSITY ALIGNMENT PANEL. |
| 1 | 3KC RECEIVE BAND TEST PANEL. |
| 3 | Demultiplexer TD–98/FGR–3. |
| 1 | DUMMY CIRCUIT PANEL. |
| 1 | LOOP BATTERY PANEL. |
| 2 | Transformer Assembly TF–206/FG (fig. 164). |
| 1 | Main power unit (fig. 164). |
| 2 | Loop battery supply (fig. 170). |

*Note.* In some system applications of the AN/FGC–29 terminal, the audio frequency amplifiers are replaced by dummy circuit panels (par. 25). The demultiplexers are sometimes replaced by audio frequency amplifiers or dummy circuit panels.

## 22. Description of Cabinet 4

(fig. 7)

Cabinet 4 contains part of the telegraph receiver group that converts incoming carrier signals into dc telegraph impulses for 16 carrier telegraph channels. The components of cabinet 4 are listed in the chart below.

| Quantity | Unit |
|---|---|
| 1 | AC POWER SWITCHING PANEL. |
| 6 | Receiver. |
| 3 | Combiner. |
| 1 | Voltage regulator (fig. 168). |

## 23. Description of Cabinet 5

(fig. 8)

Cabinet 5 contains part of the telegraph receiver group that converts incoming carrier signals into dc telegraph impulses for 16 carrier telegraph

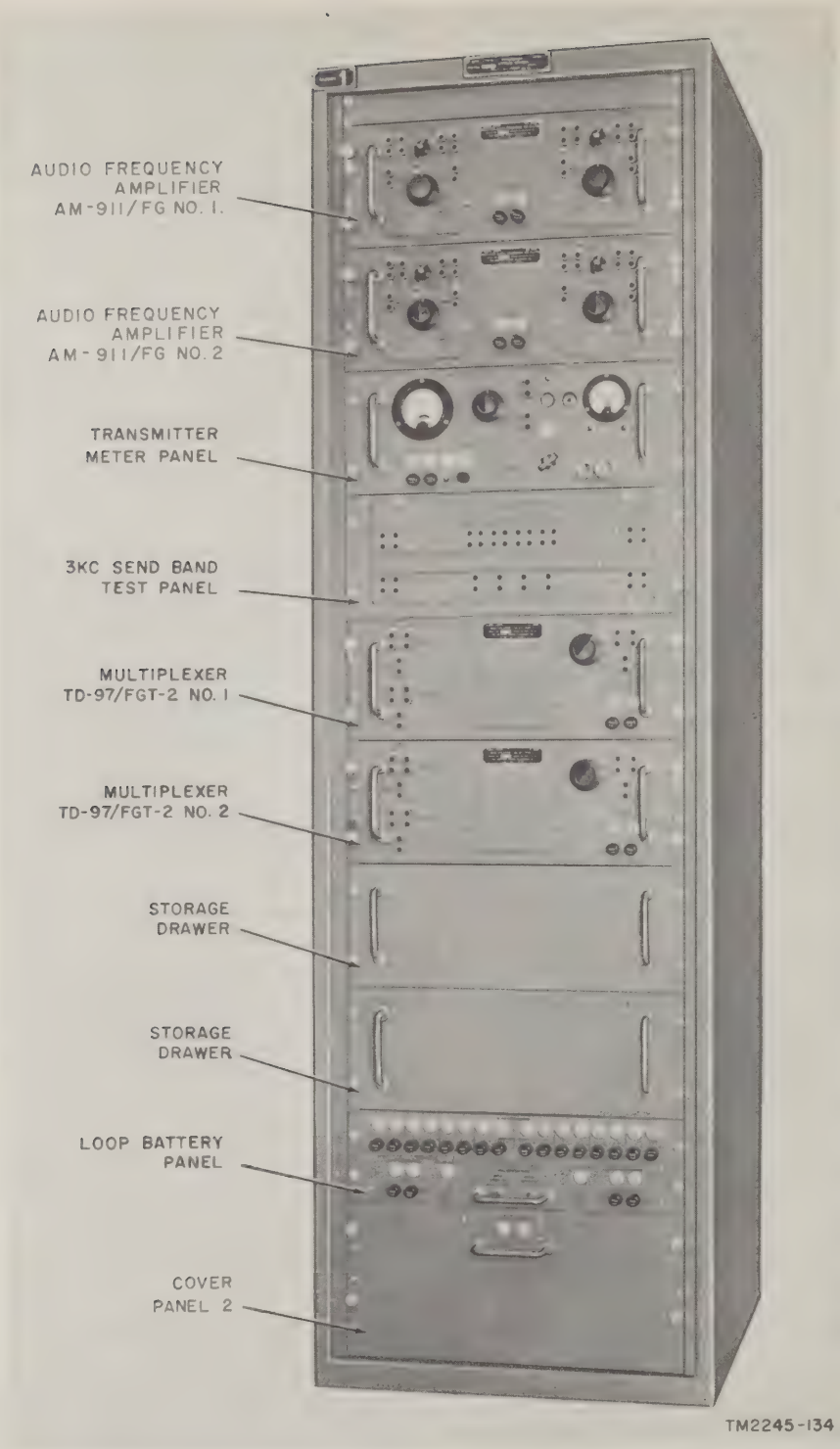



*Figure 4. Cabinet 1.*

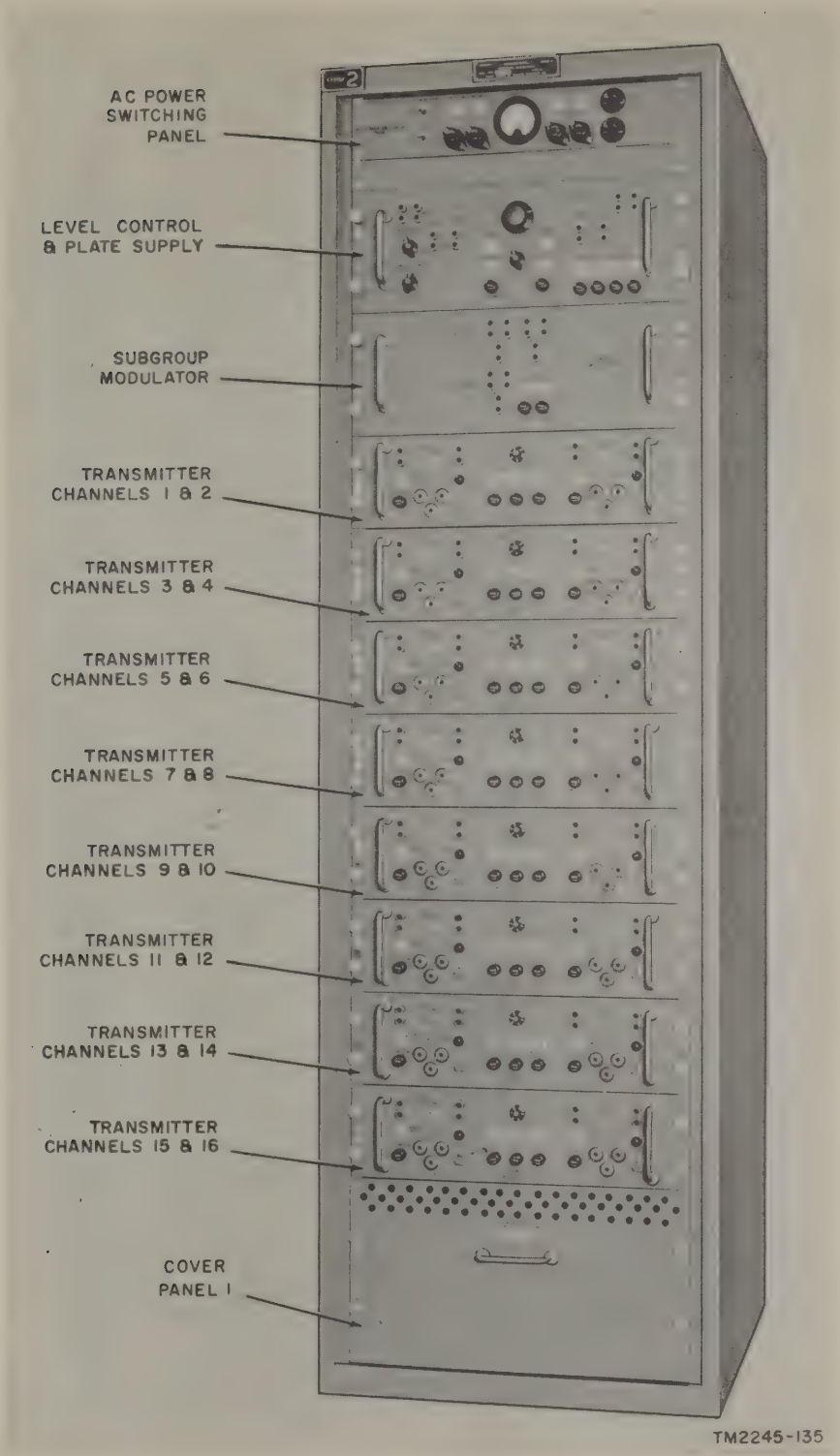

AC POWER SWITCHING PANEL
LEVEL CONTROL & PLATE SUPPLY
SUBGROUP MODULATOR
TRANSMITTER CHANNELS 1 & 2
TRANSMITTER CHANNELS 3 & 4
TRANSMITTER CHANNELS 5 & 6
TRANSMITTER CHANNELS 7 & 8
TRANSMITTER CHANNELS 9 & 10
TRANSMITTER CHANNELS 11 & 12
TRANSMITTER CHANNELS 13 & 14
TRANSMITTER CHANNELS 15 & 16
COVER PANEL 1
TM2245-135

*Figure 5. Cabinet 2.*

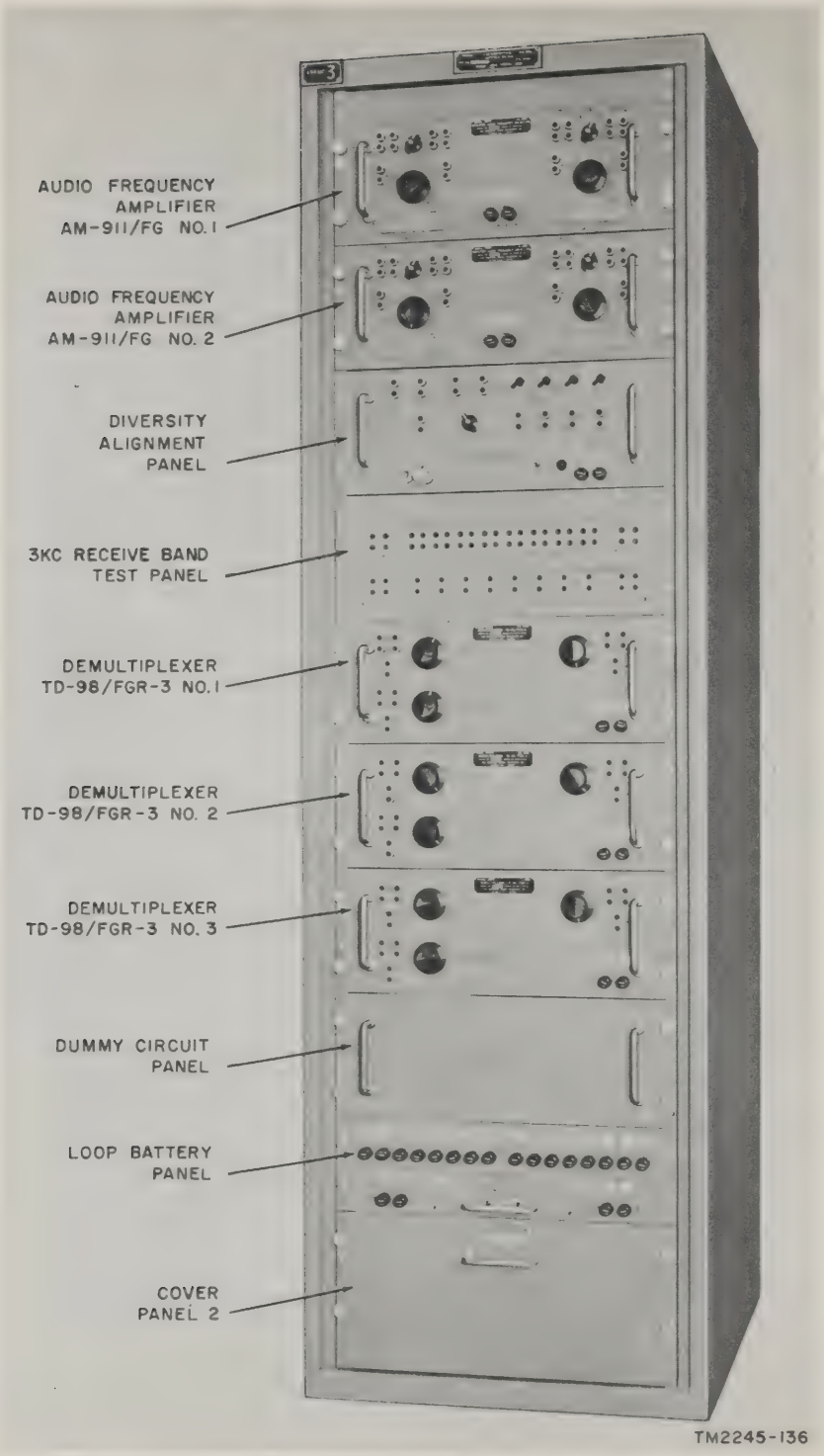



*Figure 6. Cabinet 3.*

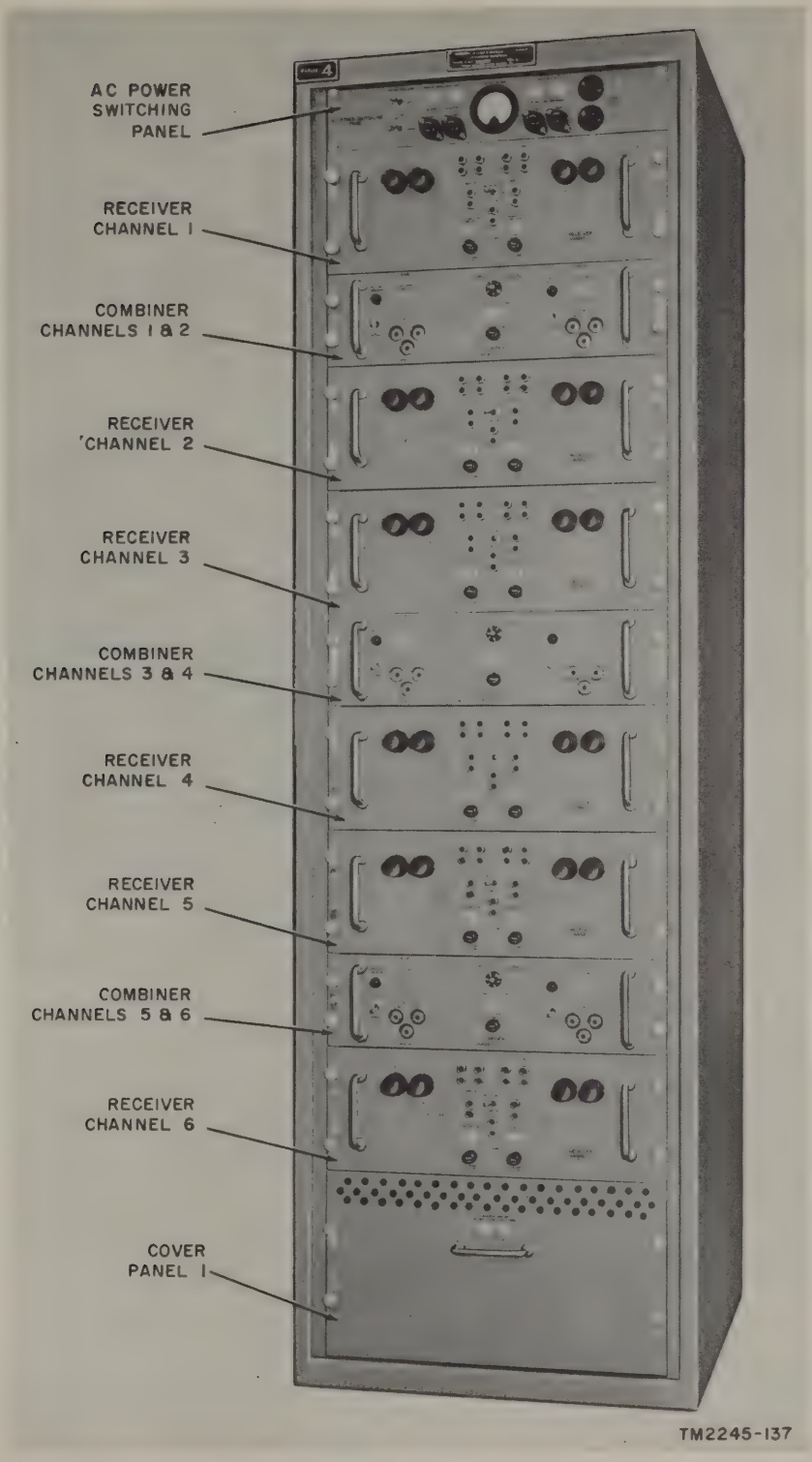



*Figure 7. Cabinet 4.*

channels. The components of cabinet 5 are listed in the chart below.

| Quantity | Unit |
|---|---|
| 2 | SUBGROUP DEMODULATOR. |
| 1 | RECEIVER METER PANEL. |
| 4 | Receiver. |
| 2 | Combiner. |
| 1 | Main power Unit (fig. 166). |
| 1 | Step-up power transformer (fig. 169). |

## 24. Description of Cabinet 6

(fig. 9)

Cabinet 6 contains part of the telegraph receiver group that converts incoming carrier signals into dc telegraph impulses for 16 carrier telegraph channels. The components of cabinet 6 are listed in the chart below.

| Quantity | Unit |
|---|---|
| 1 | AC POWER SWITCHING PANEL. |
| 6 | Receiver. |
| 3 | Combiner. |
| 1 | Voltage regulator (fig. 168). |

## 25. Description of Minor Components

Minor components are included in a separate shipping case (par. 42*a*(2)) and are required for operation and maintenance. Quantities required and appropriate references are listed in the chart below.

| Quantity | Minor components |
|---|---|
| 1 | RELAY PANEL (fig. 10). |
| 1 | Set, interconnecting cables and patching cords (fig. 11). |
| 2 | Electrical Headset H–110/G (fig. 12). |
| 7 | DUMMY CIRCUIT PANEL (fig. 6). |
| 1 | Transformer Assembly TF–206/FG (figs. 202 and 203). |

## 26. Description of Transmitter

(fig. 5)

The transmitter is a drawer-type chassis (par. 18*c*) that contains equipment for converting dc telegraph impulses into carrier telegraph signals. Each transmitter serves 2 of the 16 channels.

*a*. Transmitter subassemblies are listed in the chart below.

| Quantity | Subassembly |
|---|---|
| 2 | Keyer. |
| 2 | Oscillator tuner. |
| 2 | Transmitter filter. |
| 2 | Bias supply. |

*b*. Oscillator tuner and transmitter filter subassembly designations, for each of the transmitter channels, are listed in the chart below.

| Channel | Designation |
|---|---|
| 1 or 16 | 1/16 |
| 2 or 15 | 2/15 |
| 3 or 14 | 3/14 |
| 4 or 13 | 4/13 |
| 5 or 12 | 5/12 |
| 6 or 11 | 6/11 |
| 7 or 10 | 7/10 |
| 8 or 9 | 8/9 |

## 27. Description of SUBGROUP MODULATOR

(fig. 5)

The SUBGROUP MODULATOR is a drawer-type chassis (par. 18*c*), that contains equipment for combining two 8-channel groups of carrier telegraph signals into one 16-channel group. SUBGROUP MODULATOR subassemblies are listed in the chart below.

| Quantity | Subassembly |
|---|---|
| 1 | Carrier supply. |
| 1 | Modulator. |
| 1 | Converter. |
| 1 | Output coupler. |
| 1 | Mod filter 1. |
| 1 | Mod filter 2. |
| 1 | Plate supply. |

## 28. Description of LEVEL CONTROL & PLATE SUPPLY

(fig. 5)

The LEVEL CONTROL & PLATE SUPPLY is a drawer-type chassis (par. 18*c*), that contains equipment that performs two functions. It provides an adjustable gain to amplify the 16-channel group of carrier telegraph signals for transmission. It also supplies B-plus voltage to the transmitters

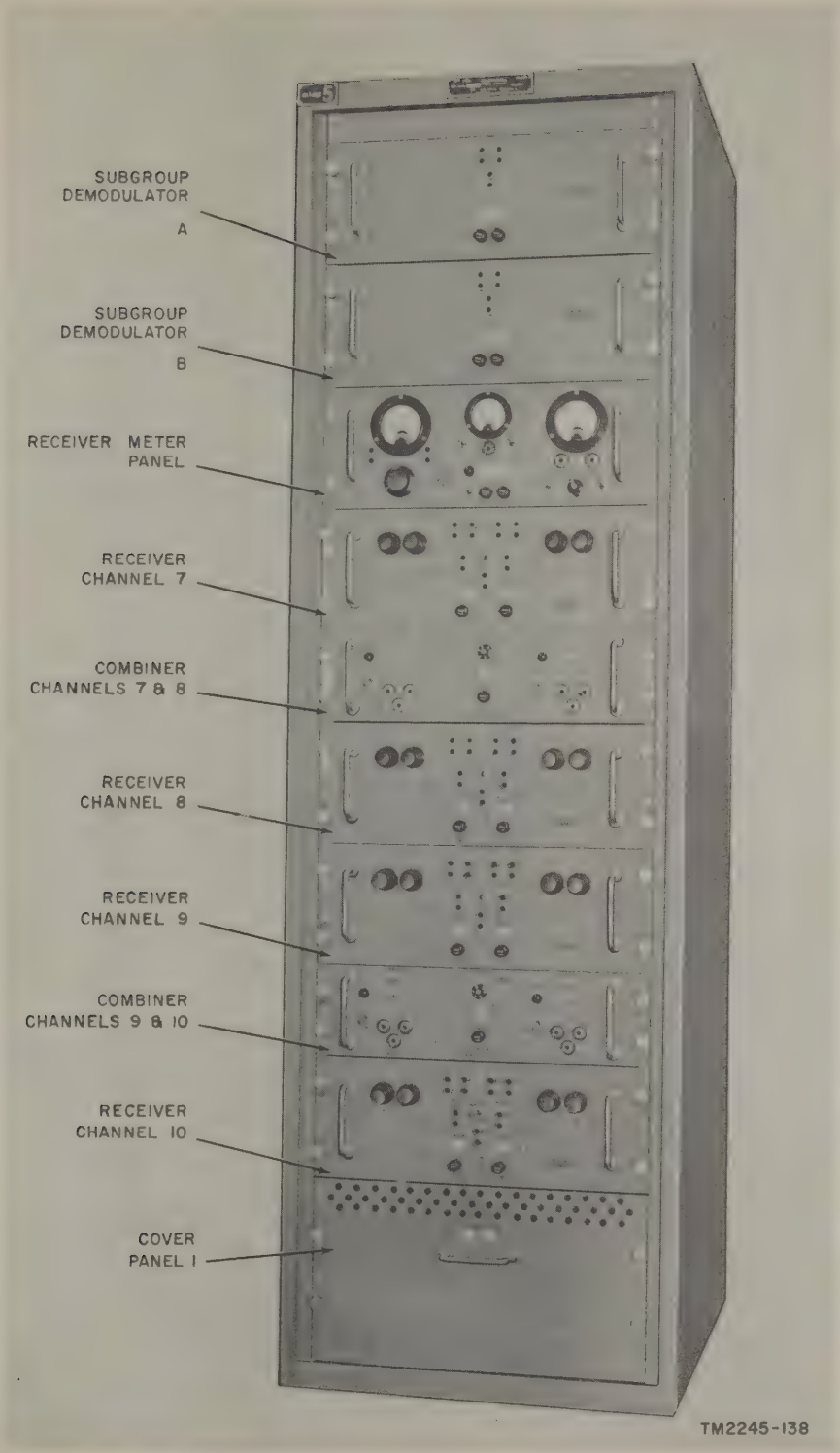



*Figure 8. Cabinet 5.*

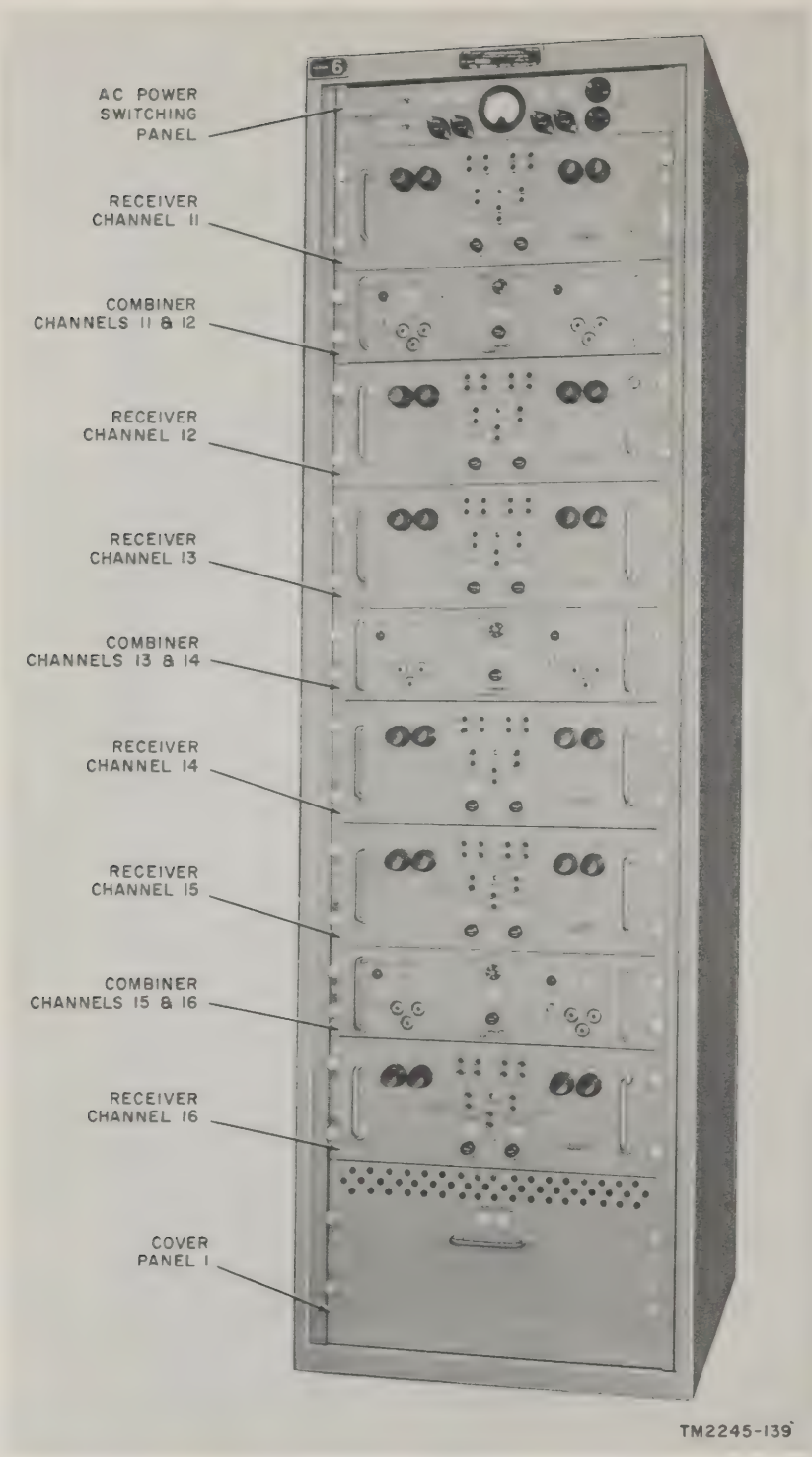



*Figure 9. Cabinet 6.*

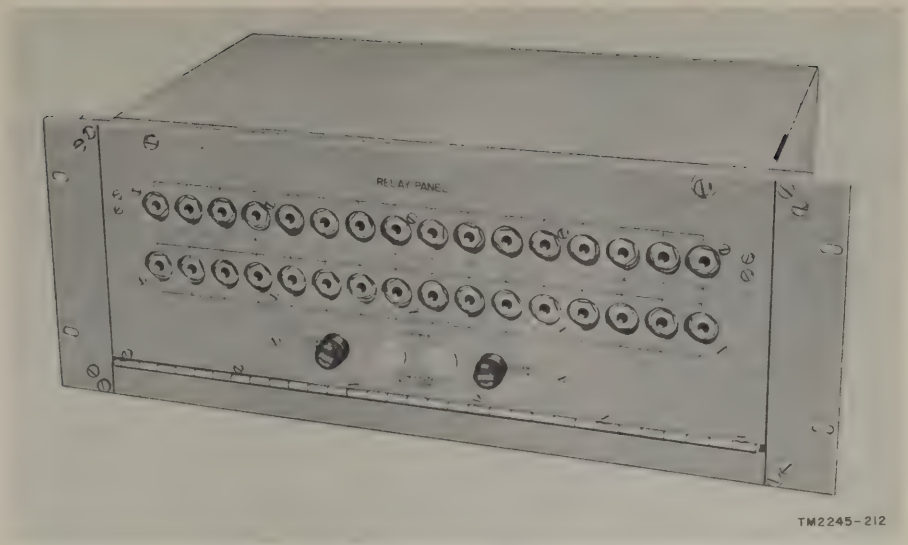



*Figure 10. Relay panel.*

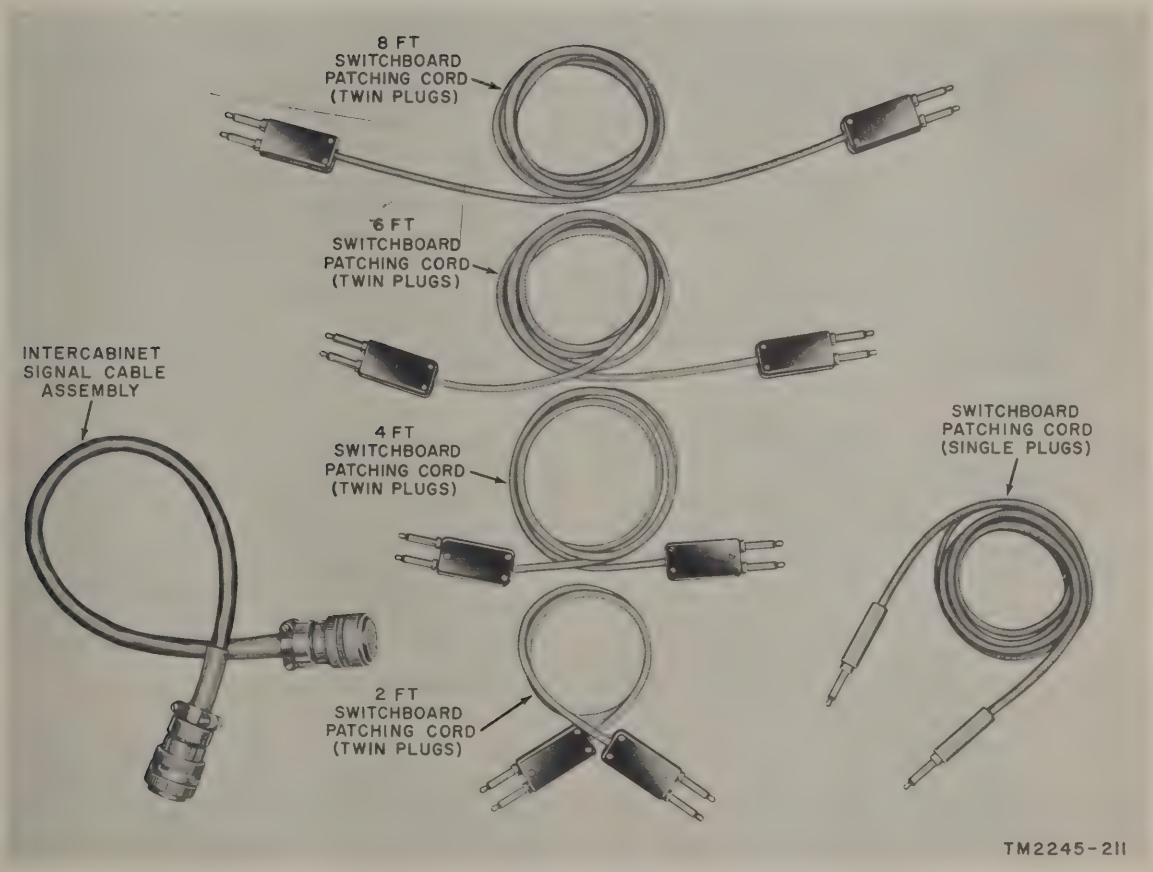



*Figure 11. Interconnecting cables and patching cords.*

*Figure 12. Electrical Headset H–110/G.*

(par. 26). LEVEL CONTROL & PLATE SUPPLY subassemblies are listed in the chart below.

| Quantity | Subassembly |
|---|---|
| 2 | Line amplifier. |
| 2 | Plate supply. |

## 29. Description of SUBGROUP DEMODULATOR

(fig. 8)

The SUBGROUP DEMODULATOR is a drawer-type chassis (par. 18*c*) that contains equipment for dividing one 16-channel group of carrier telegraph signals into two 8-channel groups. SUBGROUP DEMODULATOR subassemblies are listed in the chart below.

| Quantity | Subassembly |
|---|---|
| 1 | Carrier supply. |
| 1 | Modulator. |
| 1 | Converter. |
| 1 | Band amplifier. |
| 1 | Input network. |
| 1 | Demod filter 1. |
| 1 | Plate supply. |

## 30. Description of Receiver

(figs. 7, 8, and 9)

The receiver is a drawer-type chassis (par. 18*c*), that contains equipment for selecting and automatically controlling the gain of received diversity signals. Each receiver serves one of the 16 channels.

*a*. Receiver subassemblies are listed in the chart below.

| Quantity | Subassembly |
|---|---|
| 2 | AGC amplifier. |
| 2 | Delay amplifier. |
| 2 | Receiver filter. |
| 1 | Plate supply. |

*b*. Delay amplifier and the receiver filter subassembly designations, for each of the receiver channels, are listed in the chart in paragraph 26*b*.

## 31. Description of Combiner

(figs. 7, 8, and 9)

The combiner is a drawer-type chassis (par. 18*c*) that contains equipment for combining received carrier telegraph diversity signals and for converting them into dc telegraph impulses. Each combiner serves 2 of the 16 channels.

*a*. Combiner subassemblies are listed in the chart below.

| Quantity | Subassembly |
|---|---|
| 2 | Adder. |
| 2 | Discriminator. |
| 1 | Transformer-reactor assembly. |

*b*. Discriminator subassembly designations, for each of the combiner channels, are listed in the chart in paragraph 26*b*.

## 32. Description of Multiplexer TD–97/FGT–2

(fig. 4)

Multiplexer TD–97/FGT–2 is a drawer-type chassis (par. 18*c*) that contains equipment for combining signals from two independent vf circuits for transmission over the 6-kc bandwidth of an associated radio system. Multiplexer subassemblies are listed in the chart below.

| Quantity | Subassembly |
|---|---|
| 1 | Modulator. |
| 1 | Carrier supply. |
| 1 | Line amplifier. |
| 1 | Plate supply. |
| 1 | Input coupler. |
| 1 | Mux filter 1. |
| 1 | Mux filter 2. |
| 1 | Mux filter 3. |

## 33. Description of Demultiplexer TD–98/FGR–3

(fig. 6)

Demultiplexer TD–98/FGR–3 is a drawer-type chassis (par. 18*c*) that contains equipment for separating the combined signals of two vf circuits that have been received over the 6-kc bandwidth of an associated radio system. Demultiplexer subassemblies are listed in the chart below.

| Quantity | Subassembly |
|---|---|
| 1 | Modulator. |
| 1 | Carrier supply. |
| 1 | Line amplifier. |
| 1 | Plate supply. |
| 1 | Demux filter 1. |
| 1 | Demux filter 2. |
| 1 | Demux filter 3. |

## 34. Description of Audio Frequency Amplifier AM–911/FG

(figs. 4 and 6)

Audio Frequency Amplifier AM–911/FG is a drawer-type chassis (par. 18*c*) that contains equipment for providing impedance matching, equalizing, and amplifying facilities to compensate for the attenuation characteristics of loaded or nonloaded cable circuits. Each audio frequency amplifier serves two separate line circuits. Audio frequency amplifier subassemblies are listed in the chart below.

| Quantity | Subassembly |
|---|---|
| 2 | Line amplifier. |
| 2 | Equalizer. |
| 1 | Line transformer assembly. |
| 1 | Plate supply. |

## 35. Running Spares

A set of running spares (listed in chart below) is supplied with each Telegraph Terminal AN/FGC–29, for all normally expendable items.

| Quantity | Item |
|---|---|
| 2 | Cord, switchboard patching, plugs both ends. |
| 16 | Cord, switchboard patching, twin plugs both ends. |
| 7 | Intercabinet signal cable assembly. |
| 3 | Crystal Unit CR–50/U, 19.38 kc. |
| 8 | Crystal Unit CR–50/U, 25.16 kc. |
| 48 | Fuse, 1/16-amp. |
| 18 | Fuse, 1/8-amp. |
| 36 | Fuse, 1/4-amp. |
| 96 | Fuse, 3/8-amp. |
| 192 | Fuse, 1/2-amp. |
| 18 | Fuse, 1-amp. |
| 36 | Fuse, 3-amp. |
| 36 | Fuse, 5-amp. |
| 18 | Fuse, 10-amp. |
| 36 | Fuse, 20-amp. |
| 96 | Fuse, 1/10-amp, slow-blow. |
| 36 | Fuse, 1/4-amp, slow-blow. |
| 48 | Fuse, 3/8-amp, slow-blow. |
| 204 | Fuse, 1/2-amp, slow-blow. |
| 168 | Fuse, 1-amp, slow-blow. |
| 48 | Fuse, 3-amp, slow-blow. |
| 72 | Fuse, 5-amp, slow-blow. |
| 20 | Diode, 1N69. |
| 12 | Diode, 1N92. |
| 4 | Diode, 1N362. |
| 13 | Diode, 1N330. |
| 28 | Varistor, 1N71. |
| 6 | Varistor, 1N435. |

| Quantity | Item |
|---|---|
| 4 | Selenium rectifier, Bradley Labs, No. SE6M50H. |
| 4 | Selenium rectifier, Bradley Labs, No. SE6LA10H413. |
| 8 | Lamp, incandescent, No. 44. |
| 12 | Lamp, neon, NE51. |
| 16 | Relay, polar, Sigma type 72A04Z–160TS. |
| 8 | Tube, 2AS15. |
| 44 | Tube, 2D21W. |
| 8 | Tube, 3B22. |
| 8 | Tube, 5Y3GT. |
| 44 | Tube, 6AQ5W. |
| 28 | Tube, 6AU6W. |
| 8 | Tube, 6CL6. |
| 8 | Tube, 6X4W. |
| 8 | Tube, 807. |
| 4 | Tube, 5726. |
| 52 | Tube, 5751. |
| 31 | Tube, 5814. |

## 36. Additional Equipment Required

Additional items (*a* through *c* below) not furnished as part of the equipment, are required for the installation and operation of Multiplexer TD–97/FGT–2, Demultiplexer TD–98/FGR–3, and Audio Frequency Amplifier AM–911/FG, when these components are used at a location remote from that of the AN/FGC–29 terminal.

*a. Relay Rack Cabinet.* A relay rack cabinet, or space in an existing cabinet, is required for installation at the remote location.

*b. Volume Indicator.* Either Volume Indicator ID–220A/FRT or Volume Indicator ID–220B/FRT, or equivalent high-impedance volume unit (vu) meter, is required at each remote installation for measuring signal levels.

*c. Electrical Headset.* One Electrical Headset H–110/G, or equivalent high-impedance telephone receiver, is required at each remote installation for signal monitoring.

# CHAPTER 2
# INSTALLATION

## Section I. SYSTEM PLANNING CONSIDERATION

### 37. General

Telegraph Terminal AN/FGC–29 uses twin-channel single-sideband radio systems to provide telegraph, telephone, or facsimile service between points which may be thousands of miles apart. The transmitting terminal converts dc telegraph impulses into frequency-shift carrier signals and transmits them via radio over two diversity paths to the receiving terminal. The receiving terminal reconverts the frequency-shift carrier telegraph signals to dc telegraph impulses and uses diversity combining to provide dependable operation under conditions of selective fading. Four 2-way vf circuits are derived from the twin-channel radio by the multiplexers and demultiplexers of the AN/FGC–29 terminal. The carrier telegraph signals use one or two of these vf circuits depending on the type of diversity operation. Signals from telephone or facsimile equipment can be sent through the remaining vf circuits to telephone or facsimile receiving equipment. Audio frequency amplifiers included in the AN/FGC–29 terminal provide the equalization and amplification necessary to permit operation over interconnecting line facilities between the AN/FGC–29 terminal and remotely located radio transmitters and receivers. The multiplexers, demultiplexers, and audio frequency amplifiers are removable and can be installed at either end of the interconnecting lines. Typical examples of radio equipment that may be used with Telegraph Terminal AN/FGC–29 are Radio Transmitter T–265/FRC–10, Radio Transmitter T–409/FRC–30, Radio Receiver R–369/FRC–10, and Radio Receiving Set AN/FRR–40. Paragraphs 38 through 44 contain information for planning a system using Telegraph Terminal AN/FGC–29 as terminal equipment. Paragraphs 45 through 61 contain instructions for installing the equipment and connecting it into the system.

### 38. Telegraph Service

*a. General.* Telegraph Terminal AN/FGC–29 receives dc marking and spacing impulses from each of 16 transmitting telegraph loops. These signals control the frequencies of 16 carrier telegraph channels. The frequencies of the 16 carrier telegraph channels are assembled within a 3 kc band and are transmitted between the transmitting and receiving terminals through the vf circuits that are derived from the radio sidebands. At the receiving terminal, the frequencies of the 16 carrier telegraph channels are reconverted into dc marking and spacing impulses and applied to the receiving telegraph loops.

(1) *Two-channel diversity combining.* The transmitted signals of the 16 telegraph channels appear at the output of the telegraph transmitter group as 16 carrier tones, within a bandwidth from 375 to 3,025 cps. This vf band is transmitted over two frequency diversity or space diversity paths to the receiving end of the system, where the two sources of received signals are applied to two separate inputs of the telegraph receiver group. The two groups of received signals are identical except that they follow different fading patterns. In the telegraph receiver group, the two diversity signals for each channel are combined by the ratio-squaring method to reduce the effects of selective fading.

(2) *Four-channel diversity combining.* Under adverse fading conditions, the AN/FGC–29 terminal can be operated in 4-channel diversity. This is done in accordance with a prearranged system whereby 8 transmitting loops are made idle and the remaining 8 each operate 2

of the 16 carrier channels. In the telegraph receiver group, the four diversity signals for each channel pair are combined by the ratio-squaring method.

*Note.* When 4-channel diversity combining is used, the telegraph circuit handling capacity of the AN/FGC–29 terminal is halved. For this reason, 4-channel diversity combining should be used only when 2-channel diversity results in unsatisfactory reception.

(3) *Space diversity operation.* For space diversity operation, the carrier telegraph signals are transmitted through one of the four vf circuits derived from the radio system by the multiplexers and demultiplexers of the AN/FGC–29 terminal. A diversity radio reciever, operating from a separate receiving antenna, provides a second source of the received signals. Signals from one source are applied to the A path of the telegraph receiver group and signals from the second source are applied to the B path. A demultiplexer is used with the second radio receiver to derive the diversity vf circuit carrying the telegraph service.

(4) *Frequency diversity operation.* For frequency diversity operation, the carrier telegraph signals are applied to two of the four vf circuits derived from the radio transmitter by the multiplexers. This results in their simultaneous transmission at two different locations in the radio-frequency spectrum. The two sources of received signals for the A and B paths of the telegraph receiver group are obtained from the corresponding vf circuits of the demultiplexers associated with the radio receiver.

(5) *Loop battery.* The AN/FGC–29 terminal operates with transmitting loops terminated in positive or negative battery, or ground. For transmitting loops with positive or negative terminations, a ground is supplied at the terminal. For transmitting or receiving loops terminated in ground, —130-volt loop battery is supplied from the terminal. For receiving loops which require battery other than —130 volts, relays must be used such as those in the RELAY PANEL furnished with the AN/FGC–29 terminal.

*b. Telegraph Operating Levels.*

(1) *Sending.* For telegraph operation, the sending power level on a vf circuit derived by Multiplexer TD–97/FGT–2 is +2 decibels referred to 1 milliwatt (dbm) for a group of 16 carrier telegraph channels. This corresponds to a level of —10 dbm per telegraph channel. When telegraph signals are transmitted by space diversity, they are sent from the telegraph transmitter group to the multiplexer input at these levels. For frequency diversity operation, the 16 telegraph channels are transmitted to the multiplexer input at a power level of +8 dbm, or —4 dbm per channel. A branching network in the multiplexer connects the signals to two multiplexer paths so that they are transmitted through both paths simultaneously. This introduces a loss of 6 decibels (db) and reduces the signal levels to the required +2 dbm for 16 channels, or —10 dbm per channel.

(2) *Receiving.* The receiving power level on a vf circuit derived by Demultiplexer TD–98/FGR–3 is a +12 dbm for a group of 16 channels. This corresponds to a level of 0 dbm per channel, and is the correct input level for the receiving terminal.

## 39. Installation Planning

*a. Typical Installation.* The AN/FGC–29 terminal at each end of the long range carrier telegraph system is usually installed at a communication center. The radio transmitter and receiver terminals, used with the system, are located a considerable distance apart at remote locations where space is available for antennas and where radio interference is minimized. The communication center is generally located at a major headquarters in a large city or on a military reservation. This is the point at which the message traffic originates, terminates, or is relayed. The telephone or facsimile terminal equipment, which may be used with such a system, is also usually installed at such a communication center. The multiplexers, demultiplexers, and audio frequency amplifiers of the AN/FGC–29 terminal may be located either at the communication center or at the radio terminals. The number of multiplexers, demultiplexers, or audio frequency

amplifiers, needed at any particular installation, depends on the type of operation and the interconnecting line facilities available. The arrangement of these units for different installations and facilities are discussed in paragraphs 40 and 41.

*b. Multiplexer TD–97/FGT–2.* The transmission of four vf circuits over the system is accomplished by the two multiplexers of the transmitting terminal, which are used with the twin-channel radio transmitter. One multiplexer combines two vf circuits, each with a bandwidth of 3 kc, into a single output having a bandwidth of 6 kc. This multiplexed band is then applied to one of the 6-kc channels of the radio transmitter. The second multiplexer performs the same function for the second channel of the radio transmitter. The multiplexers may be installed in cabinet 1 of the transmitting terminal, or in a cabinet at the radio transmitter site.

(1) When the multiplexers are installed in cabinet 1 of the transmitting terminal, the output of the transmitting terminal is carried to the radio transmitter over 6-kc line facilities (par. 40).

(2) When the multiplexers are installed in a cabinet at the radio transmitter site, the output of the telegraph transmitter group is brought to the multiplexers over 3-kc line facilities (par. 41).

*c. Demultiplexer TD–98/FGR–3.* The reception of signals for four vf circuits is accomplished by the demultiplexers in the receiving terminals, which are used with a twin-channel radio receiver. One demultiplexer accepts signals from one of the 6-kc channels of the radio receiver and divides the input into two outputs, each with a bandwidth of 3 kc. The second demultiplexer performs the same function for the other channel of the radio receiver. A third demultiplexer is used to receive telegraph signals whenever two radio receivers are operated in space diversity (par. 38*a*(3)). The demultiplexers may be installed either in cabinet 3 of the receiving terminal at the communication center or in a cabinet installed at the radio receiver site.

(1) When the demultiplexers are located in cabinet 3 of the receiving terminal, the incoming signals are brought to the input of the receiving terminal over 6-kc line facilities (par. 40).

(2) When the demultiplexers are installed at the radio receiver site the demultiplexer output signals are carried to the input of the telegraph receiver group over 3-kc line facilities (par. 41).

*d. Audio Frequency Amplifier AM–911/FG.* Audio Frequency Amplifiers AM–911/FG are used whenever signals are transmitted over line facilities. They are installed at the receiving end of the line to provide equalization and gain and are adjusted for a net line loss of zero. One audio frequency amplifier provides correction for two separate line circuits. Equalization is provided for 6-kc or 3-kc operation over nonloaded cable circuits or 3-kc operation over loaded cable circuits within the limits indicated in paragraph 15.

## 40. Line Facilities, 6-Kc

*a. General.* A 6-kc line facility is a transmission line circuit that is capable of carrying a band of audio frequencies from 300 to 6,000 cps. When 6-kc line facilities are available, the multiplexers and demultiplexers are installed in cabinets 1 and 3, respectively, of the AN/FGC–29 terminal and operated over the 6-kc lines to the remote radio transmitter and receiver sites. A 6-kc bandwidth is required to supply signals to the radio transmitter or to receive signals from the radio receiver. Audio frequency amplifiers are used to compensate for the line loss. They contain equalizers that correct for the frequency attenuation characteristics of nonloaded cable pairs, within the required 6-kc bandwidth. The equalizers for nonloaded cable permit operation over nonloaded cable pairs of various types and gages, and also over properly transposed open wire lines within the limits indicated in paragraph 15.

*b. Transmitting Terminals.* Figure 13 shows a typical example of a transmitting terminal arranged for operation over 6-kc interconnecting facilities. Telegraph signals from 16 transmitting loops are applied to the telegraph transmitter group. The output of the telegraph transmitter group is applied to multiplexer No. 1. Signals from telephone or facsimile equipment are applied to the remaining inputs of multiplexers Nos. 1 and 2. Two 6-kc lines (lines Nos. 1 and 2) connect the transmitting terminal with the radio transmitter site. Signals from multiplexer No. 1 for sideband A of the radio transmitter are sent over line No. 1 and signals from multiplexer No. 2 for sideband B are sent over line No. 2. One audio frequency is used for both 6-kc lines. In this application, the second audio frequency amplifier is unused and remains available for use as a spare.

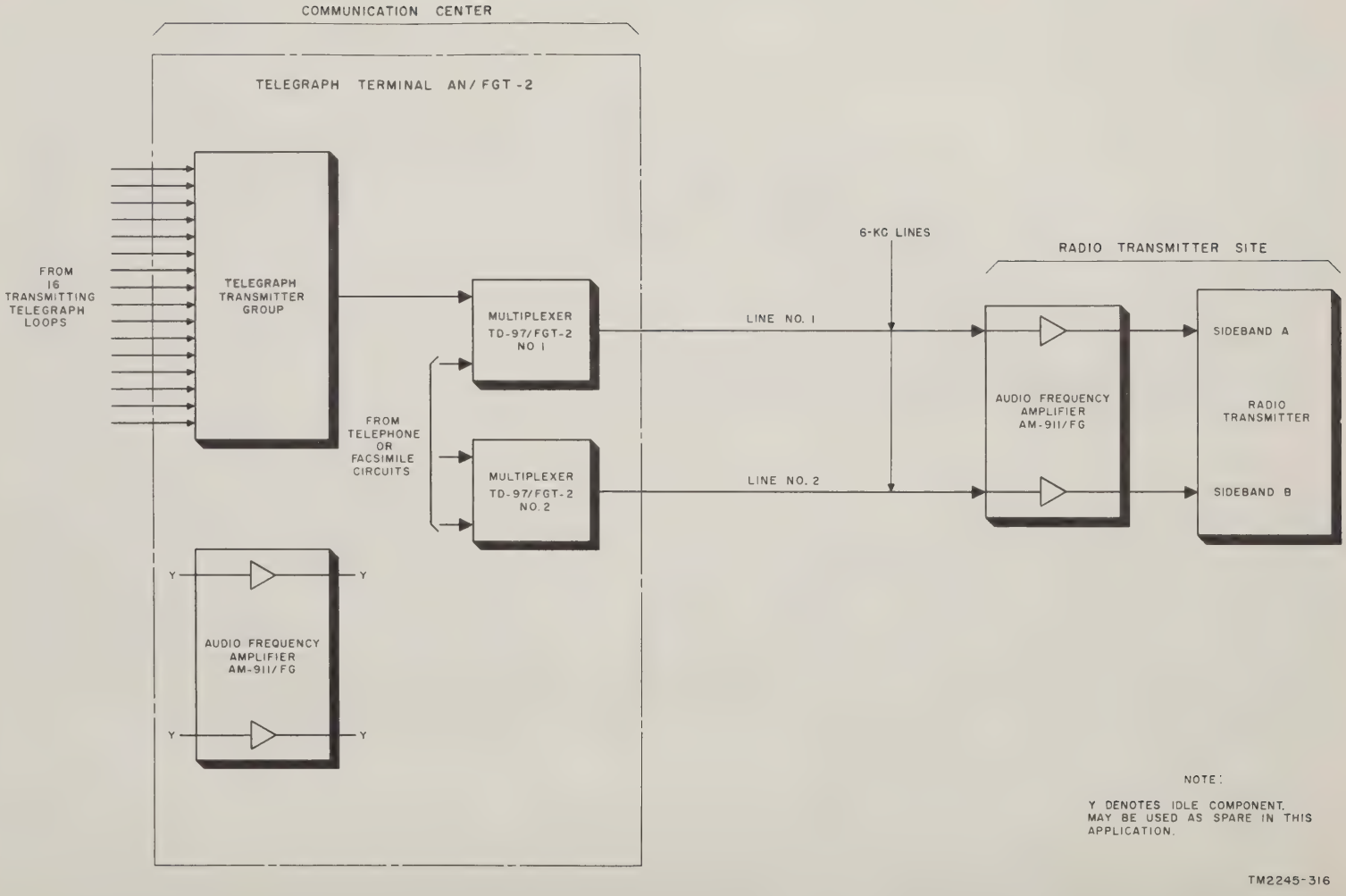



*Figure 13. Transmitting terminal, operation over 6-kc lines.*

*c. Receiving Terminal.* Typical examples of receiving terminal operational arrangements are explained in (1) and (2) below for space diversity and frequency diversity, respectively.

(1) *Space diversity* (fig. 14). For space diversity operation over 6-kc lines, the receiving terminal is used with two radio receivers. The radio receivers are connected to the receiving terminal with three 6-kc lines (lines Nos. 1–3). Lines Nos. 1 and 2 from radio receiver No. 1 carry signals for demultiplexers Nos. 1 and 2, respectively, and audio frequency amplifier No. 1. Line No. 3 from radio receiver No. 2 carries diversity signals for demultiplexers No. 3 and audio frequency amplifier No. 2. Telegraph signals from both radio receivers, differing only in their fading patterns, are sent over two lines to the receiving terminal. The telegraph signals are sent over line No. 1 for demultiplexer No. 1 and the A path of the telegraph receiver group, and over line No. 3 for demultiplexer No. 3 and the B path. Signals for telephone or facsimile equipment are sent over lines Nos. 1 and 2. Possible alternative routings are explained in paragraph 55 and illustrated in figure 39. Signals for the 16 receiving loops are supplied from the telegraph receiver group.

(2) *Frequency diversity* (fig. 15). For frequency diversity operation, a single radio receiver is used with the receiving terminal. The radio receiver is connected to the receiving terminal with two 6-kc lines (lines Nos. 1 and 2). Signals for demultiplexers Nos. 1 and 2 are equalized and amplified by audio frequency amplifier No. 1. Demultiplexer No. 3 and audio frequency amplifier No. 2 are unused, in this application, and are available for use as spared. Telegraph signals from two of the demultiplexer outputs, differing only in their fading patterns, are applied to the A and B paths of the telegraph receiver group. The telegraph signals are received over sideband A, line No. 1, and demultiplexer No. 1. Signals for telephone or facsimile circuits are sent over line No. 2 and demultiplexer No. 2. Possible alternative routings are explained in paragraph 57 and illustrated in figure 41. Signals for the 16 receiving telegraph loops are supplied from the telegraph receiver group.

## 41. Line Facilities, 3-Kc

*a. General.* A 3-kc line facility is a transmission line circuit that is capable of carrying a band of voice frequencies from 300 to approximately 3,000 cps. When the AN/FGC–29 terminal is operated over 3-kc line facilities, multiplexers are installed at the radio transmitter site and demultiplexers are installed at the receiver sites. The derived vf circuits are connected to the AN/FGC–29 terminal, at the communications center, with the 3-kc line facilities. Audio frequency amplifiers compensate for the line loss. They contain equalizers that correct for the frequency attenuation characteristics of loaded cable pairs, within the required 3-kc bandwidth. The equalizers for loaded cable permit operation over loaded cable pairs of various types and gages (par. 15). In addition, any line facility equalized for 6-kc operation can be used equally well as a 3-kc line facility. Three-kc channels of carrier telephone or radio relay systems can also be used instead of 3-kc line facilities (par. 44).

*b. Transmitting Terminal.* Figure 16 shows a typical example of a transmitting terminal arranged for operation over 3-kc line facilities. Telegraph signals from 16 transmitting loops are applied to the telegraph transmitter group of the transmitting terminal. Four 3-kc lines (lines Nos. 1–4) connect the transmitting terminal with the radio transmitter site. For frequency diversity operation, line No. 4 is not required. The output of the telegraph transmitter group is sent over line No. 1 from multiplexer No. 1. Signals from telephone and facsimile equipment are applied over lines Nos. 2 through 4 for multiplexers Nos. 1 and 2. Signals from multiplexers Nos. 1 and 2 are applied to sidebands A and B, respectively, of the radio transmitter. Audio frequency amplifier No. 1 is used for lines Nos. 1 and 2, and audio frequency amplifier No. 2 for lines Nos. 3 and 4.

*c. Receiving Terminal.* Typical examples of receiving terminal operational arrangements are explained in (1) and (2) below for space diversity and frequency diversity, respectively.

(1) *Space diversity* (fig. 17). For space diversity operation over 3-kc interconnecting facilities, the receiving terminal is

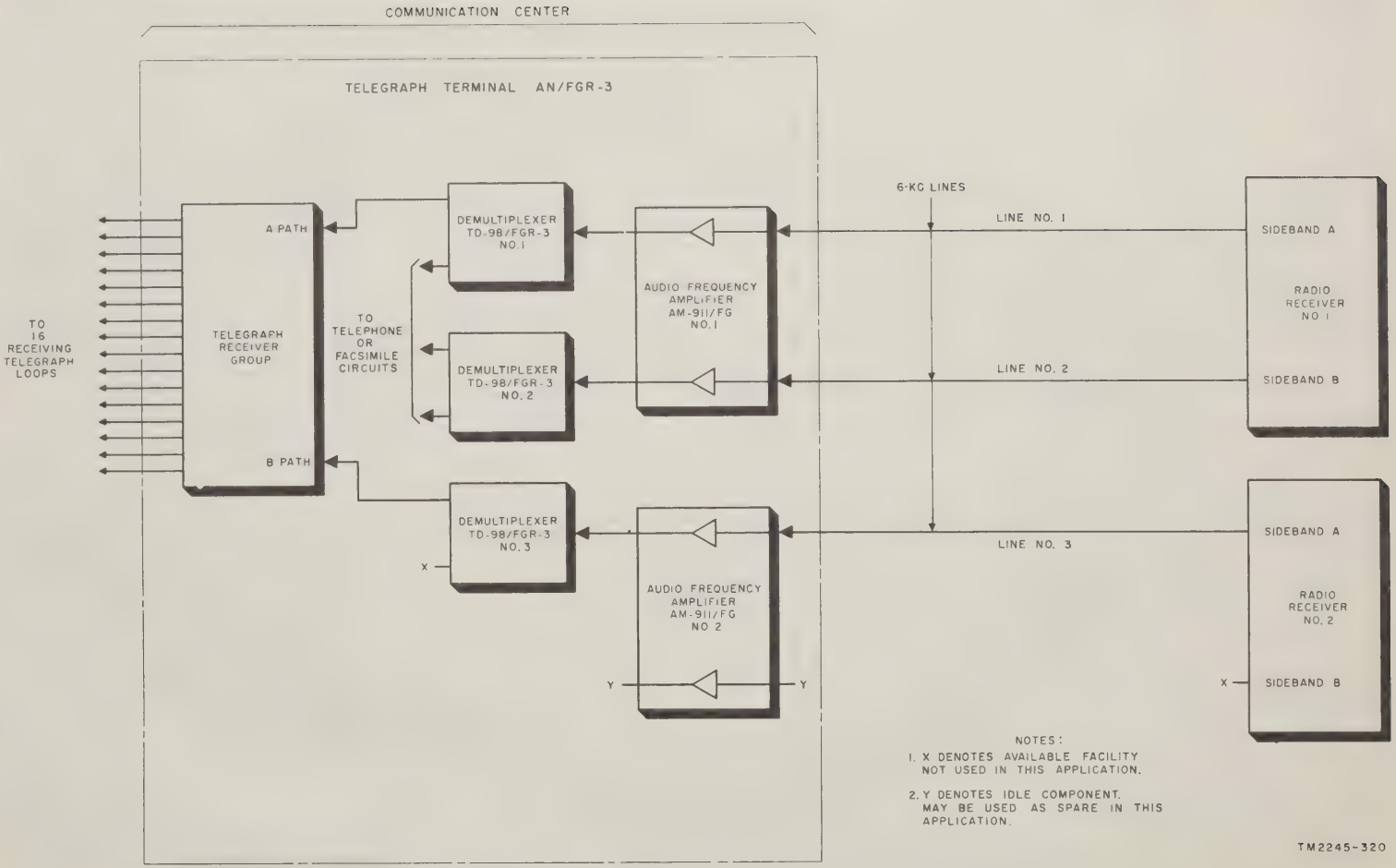



*Figure 14. Receiving terminal, space diversity operation over 6-kc lines.*

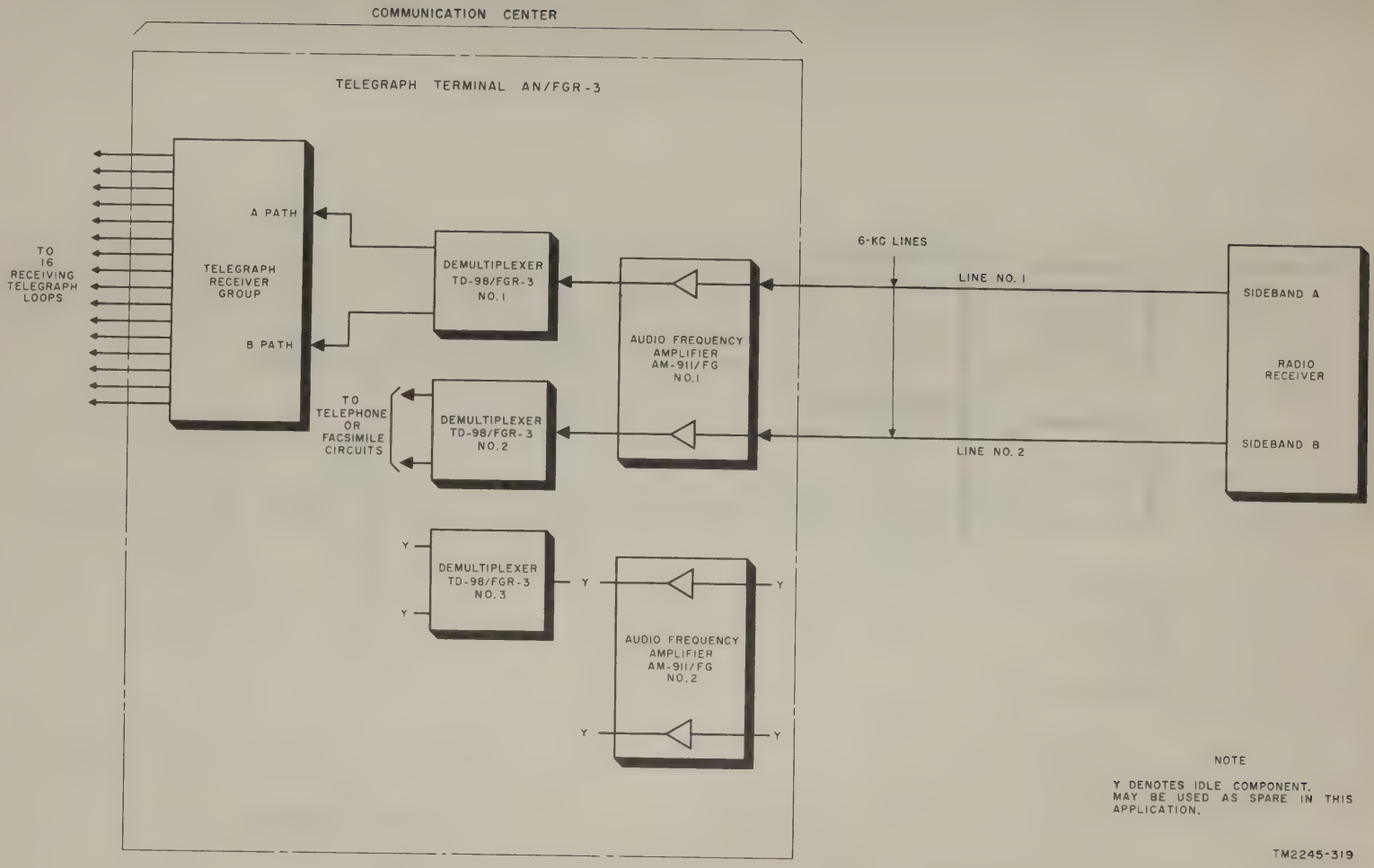



*Figure 15. Receiving terminal, frequency diversity operation over 6-kc lines.*

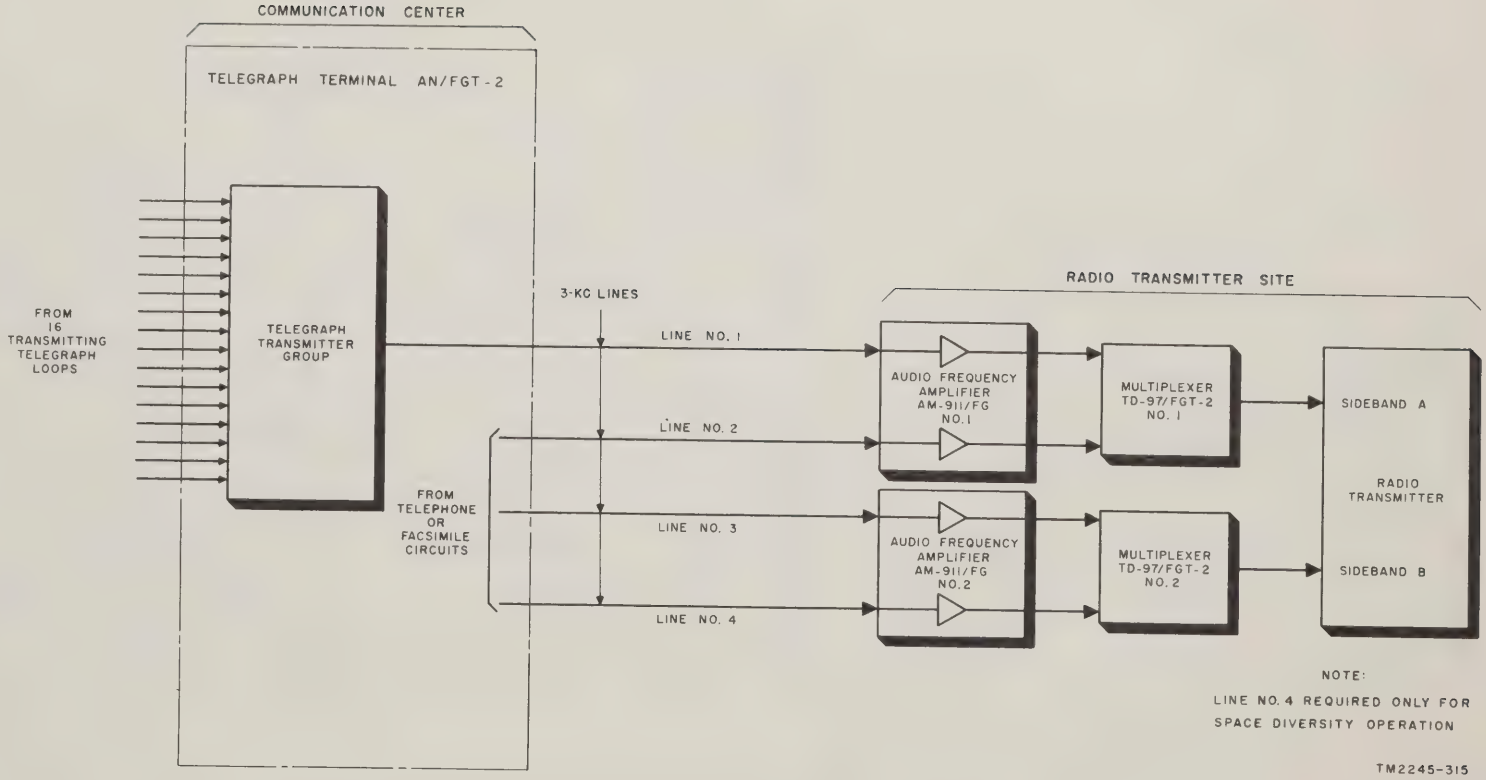



*Figure 16. Transmitting terminal, operation over 3-kc lines.*

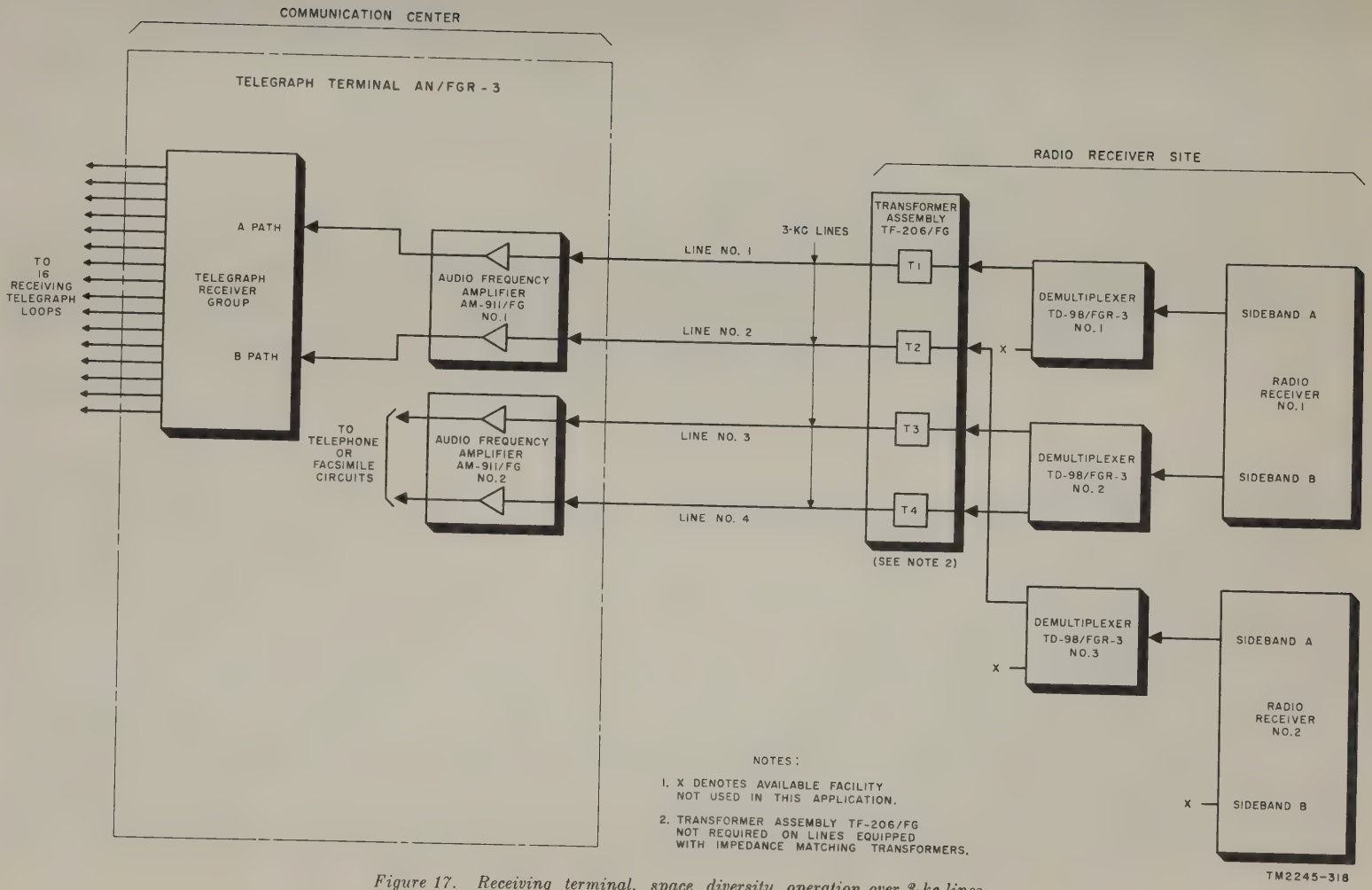



*Figure 17. Receiving terminal, space diversity operation over 3-kc lines*

used in conjunction with radio receivers Nos. 1 and 2. Demultiplexers Nos. 1 through 3 are located at the radio receiver site. Signals from radio receiver No. 1 are routed through demultiplexers Nos. 1 and 2, and signals from radio receiver No. 2 (diversity receiver) are routed through demultiplexer No. 3, as described in the manual for the demultiplexer (TM 11–2265). The demultiplexer outputs are applied to four 3-kc lines (lines Nos.1–4). The telegraph signals are received over lines Nos. 1 and 2, and the telephone or facsimile signals over lines Nos. 3 and 4. For possible alternative routing, refer to the manual for the demultiplexer (TM 11–2265). Audio frequency amplifiers Nos. 1 and 2 provide the equalization and amplification needed for all four lines. Audio frequency amplifier No. 1 is used with lines Nos. 1 and 2, and audio frequency amplifier No. 2 is used with lines Nos. 3 and 4. Telegraph signals from two demultiplexer outputs, differing only in their fading patterns, are applied to the A path and B path circuits of the telegraph receiver group. The telephone or facsimile signals are applied to telephone or facsimile circuits. Telegraph signals at the output of the telegraph receiver group are fed to 16 receiving telegraph loops.

(2) *Frequency diversity* (fig. 18). For frequency diversity operation over 3-kc interconnecting facilities, the receiving terminal is used in conjunction with a single radio receiver. Demultiplexers Nos. 1 through 3 are located at the radio receiver site. Signals from the sidebands of the radio receiver are routed through demultiplexers Nos. 1 and 2, as described in the manual for the demultiplexers (TM 11–2265). Demultiplexer No. 3 is not used in this application and is available for use as a spare. The demultiplexer outputs are applied to the receiving terminal over four 3-kc lines (lines Nos. 1–4). The telegraph signals are received over lines Nos. 1 and 2, and the telephone or facsimile signals over lines Nos. 3 and 4. For possible alternative routings, refer to the manual for demultiplexers (TM 11–2265). Audio frequency amplifiers Nos. 1 and 2 are used for all four lines. Audio frequency amplifier No. 1 is used with lines Nos. 1 and 2, and audio frequency amplifier No. 2 is used with lines Nos. 3 and 4. Two sets of telegraph signals, differing only in their fading patterns, are applied to the A and B paths of the telegraph receiver group. The telephone or facsimile signals are applied to telephone or facsimile circuits. Telegraph signals at the output of the telegraph receiver group are applied to 16 receiving telegraph loops.

*Note.* Demultiplexer TD–98/FGR–3 has a 600-ohm input and output and cannot operate directly into 3-kc transmission lines. When lines are not equipped with impedance matching transformers, some means of matching the demultiplexers to the lines, such as Transformer Assembly TF–206/FG (provided with the terminal), must be used at the radio receiver.

## 42. Line Impedance Matching

Since the AN/FGC–29 terminal may be operated in connection with various types and gages of cable and open wire lines having different impedances, a means of matching the impedance of the terminal to the impedance of the line is necessary. The nominal impedances of the line facilities commonly used vary over a range from 135 to 1,450 ohms. A sufficiently accurate match is obtained with the line-matching transformers in Transformer Assembly TF–206/FG. These transformers present three impedances; 150 ohms, 600 ohms, and 1,350 ohms. One Transformer Assembly TF–206/FG is included in the transmitting terminal for matching impedances to four lines, and two are included in the receiving terminal for matching impedances to as many as eight lines. The transformer impedance used for each type of line is listed in the chart below. The audio frequency amplifier has its own impedance matching transformers. When the audio frequency amplifier is located in the receiving terminal, arrange the impedance of the amplifier for 600 ohms to match the output impedance of Transformer Assembly TF–206/FG, and arrange the input impedance of the Transformer Assembly TF–206/FG to match the line. When audio frequency amplifiers, multiplexers, or demultiplexers are installed at the remote radio terminal, follow the instructions in TM 11–2265 for matching the impedances of these equipments to the line. An additional Transformer Assembly TF–

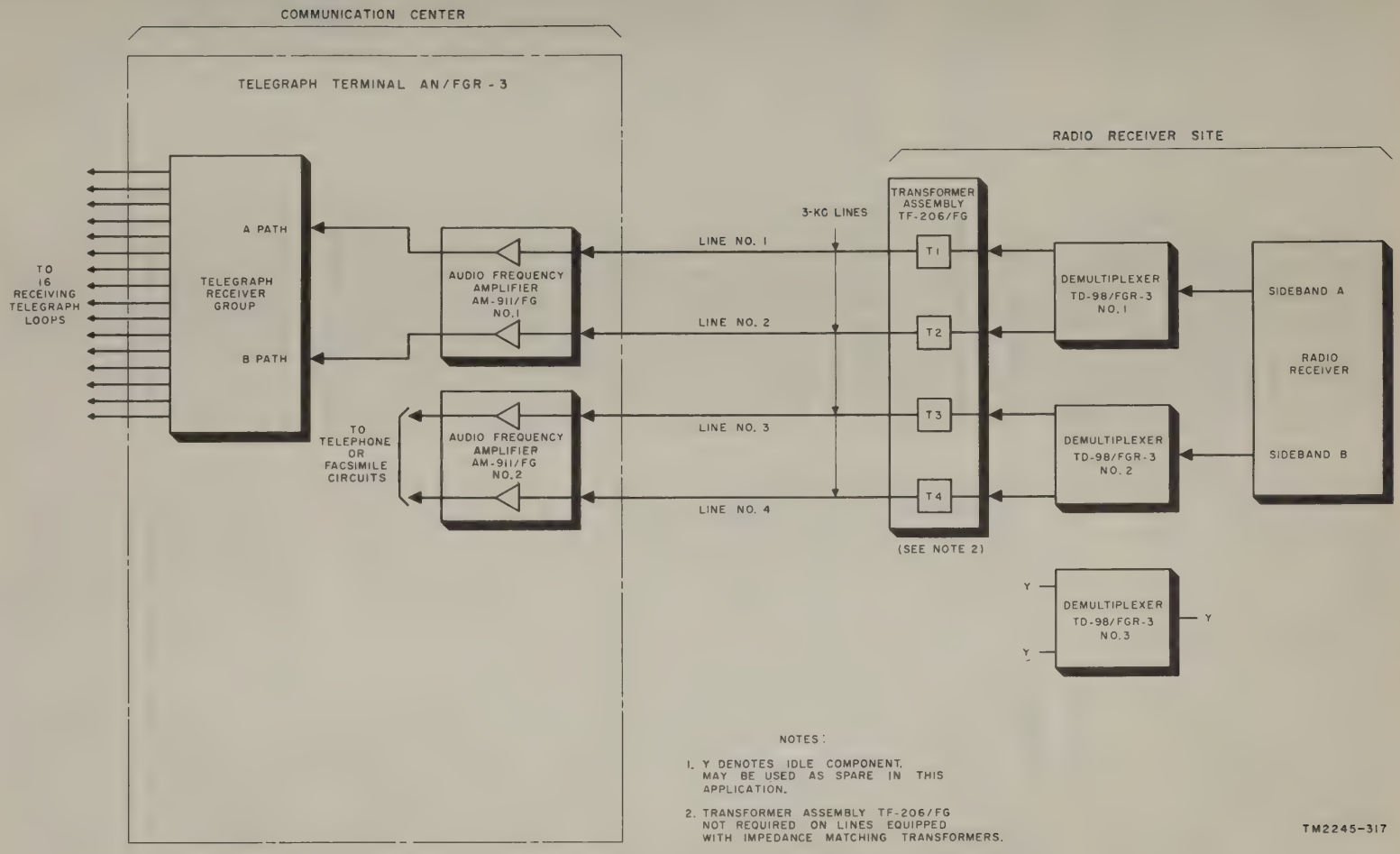



*Figure 18. Receiving terminal, frequency diversity operation over 3-kc lines.*

206/FG is included with the A AN/FGC–29 terminal for installation at the remote radio terminal if needed.

| Type of line | Transformer impedance (ohms) |
|---|---|
| Nonloaded cable (all types) | 150 |
| Loaded cable: | |
| H–44 loading | 600 |
| H–88 loading | 1, 350 |
| Open wire | 600 |

## 43. Telephone or Facsimile Service

Any of the circuits derived by the multiplexers and demultiplexers of the AN/FGC–29 terminal may be used to provide telephone or facsmile service when not used for telegraph operation. Use of all four of the vf circuits at the same time results in a radiation bandwidth of 12 kc at the output of the radio transmitter. Since this may cause interference with other services it may be necessary to restrict the number of vf circuits used. Telephone service and telephone transmission levels are discussed in *a* and *b* below. Facsimile service and facsimile operating levels are discussed in *c* and *d* below.

*a. Telephone Service.* A vf circuit terminating at a transmitting terminal input and the corresponding receiving terminal output may be used as a 4-wire telephone circuit. A 4-wire circuit provides separate paths for the two directions of transmission. For 2-wire operation, a conventional hybrid coil arrangement is required with the transmitting terminal and receiving terminal to combine the two 1-way paths and permit the transmission of speech currents in both directions over a single pair of wires. The hybrid coils provide a 2-wire termination for the switchboard or telephone.

*b. Telephone Transmission Levels.* For telephone service, the transmission levels at the 4-wire connection to the transmitting terminal and receiving terminal are −4 db for the transmitting circuit and +1 db for the receiving circuit. In a telephone system, the transmission level at any point is defined as the gain (or loss) in db from some reference point to the point under consideration. In the system used with Telegraph Terminal AN/FGC–29, the 2-wire transmitting input is the reference point and a 4-db loss in the hybrid coil arrangement is assumed. The levels for the 2-wire connection are 0 db for transmitting and −3 db for receiving.

*c. Facsimile Service.* The AN/FGC–29 vf circuits are used for facsimile service with facsimile terminal equipment using the frequency-shift method of operation. Signals from the facsimile transmitter are applied to one of the four vf circuits appearing at the multiplexer inputs. Signals for the facsimile receiver are obtained from the corresponding demultiplexer output. Facsimile equipment commonly uses a frequency shift of 800 cps and signal frequencies in the range from 1,500 to 2,300 cps.

*d. Facsimile Operating Levels.* For facsimile operation, the signal power level transmitted to the transmitting terminal input by the facsimile transmitter is 0 dbm. The receiving level at the receiving terminal is also 0 dbm for the facsimile receiver.

## 44. Carrier Telephone or Radio Relay Facilities

When the multiplexer and demultiplexers are located remotely, channels of carrier telephone or radio relay systems may be used as 3-kc facilities to carry telephone, facsimile, or carrier telegraph signals between the AN/FGC–29 terminal and the remotely located multiplexers and demultiplexers. Examples of carrier telephone systems which can be used are those using Telephone Terminal AN/TCC–3 or AN/TCC–7 as terminal equipment.

*a. Telegraph Operation.* The carrier telephone or radio relay systems which are generally used with Telegraph Terminal AN/FGC–29 operate at transmission levels of −4 db for the transmitting circuit and +1 db for the receiving circuit. For 16-channel telegraph operation, these systems use a *specific telegraph level* of −18 dbm. *Specific telegraph level is defined as the power in dbm per carrier telegraph channel at a point of 0-db transmission level.* Consequently, the output level of the telegraph transmitter group must be reduced to −22 dbm per channel for the transmitting circuit of the carrier telephone system. This is done by adjusting the output of the telegraph transmitter group which feeds signals to the carrier telephone channel. The telegraph signal level obtained from the receiving circuit of the carrier telephone systems is −17 dbm per channel. The audio frequency amplifier must be used to raise this level up to 0 dbm per channel for the input of the telegraph receiver group (par. 38*b*).

*b. Telephone or Facsimile Operation.* The military carrier telephone systems, which are usually

used with Telegraph Terminal AN/FGC–29, provide a net gain of 5 db for the telephone channel. Such channels are used to carry telephone or facsimile signals from the communication center to the radio transmitter site or from the radio receiver site to the communications center. At the radio transmitter, a 5-db pad is required at the output of the carrier telephone channel to obtain the correct multiplexer input level. Similarly, at the radio receiver, a 5-db pad is required between the output of the demultiplexer channel and the input of the associated carrier telephone channel. This procedure is the same as that customarily followed in connecting carrier telephone channels in tandem, and pads for the purpose are usually provided as part of the control board. An alternative is to set the receiving levels of the telephone channel and the receiving terminal 5 db below their normal levels.

## Section II. SERVICE UPON RECEIPT OF EQUIPMENT

### 45. Siting

The selection of a site for the installation of Telegraph Terminal AN/FGC–29 is determined by the location selected for the communications center in which the equipment is used. The AN/FGC–29 terminal is designed to operate within a temperature range of 32° to 120° Fahrenheit but, like all fixed plant equipment, will usually be operated in a sheltered room at normal room temperature. Make sure that the shelter for the equipment meets the following requirements:

*a.* The floor must be capable of supporting without sag or vibration the weight of the equipment (5,000 pounds).

*b.* The equipment requires a floor space 11 feet 3 inches wide by 2 feet deep, and, in addition, there must be enough space to permit inspection and maintenance. Allow enough space (fig. 19) behind the equipment to permit opening of the rear cabinet doors, and in front of the equipment to permit the components to be withdrawn on their drawer slides.

*c.* Place the equipment where normal air circulation is not hindered. Do not obstruct the vents on the roof and rear door of each cabinet.

*d.* A source of alternating current (ac) power at 107 to 122, or 210 to 250 volts, 50 or 60 cps, must be available. Provide a source of power capable of supplying 4,500 watts, or three separate sources each capable of supplying 1,500 watts.

*e.* Provide adequate lighting, with the light falling directly on the front panels. A source of adequate light for performing maintenance and inspection at the rear of the cabinets is also required at the time these services are performed.

### 46. Uncrating, Unpacking, and Checking New Equipment

(fig. 20)

Equipment may be packed either for oversea shipment or for domestic shipment. When new equipment is received, select a location for unpacking that is convenient to the installation. *Be careful when uncrating, unpacking, and handling the equipment. If it becomes damaged, a complete overhaul may be required, or the equipment may be rendered useless.*

*Note.* For used or reconditioned equipment, refer to paragraph 61.

*a. Packaging Data.* When packaged shipment, the components of Telegraph Terminal AN/FGC–29 are contained in seven shipping cases. Each of the six cabinets, which make up an AN/FGC–29 terminal, is contained in a separate case. The accessories and running spares are contained in the seventh case. The size, volume, and weight of each shipping case are indicated in (1) below. The contents of each case are indicated in (2) below.

(1) *Size, volume, and weight of each shipping case.*

| Case No. | Height (in.) | Width (in.) | Depth (in.) | Volume (cu ft) | Unit weight (lb) |
|---|---|---|---|---|---|
| 1 | 91 | 37 | 41 | 95 | 1, 088 |
| 2 | 91 | 37 | 41 | 95 | 1, 235 |
| 3 | 91 | 37 | 41 | 95 | 1, 175 |
| 4 | 91 | 37 | 41 | 95 | 1, 295 |
| 5 | 91 | 37 | 41 | 95 | 1, 326 |
| 6 | 91 | 37 | 41 | 95 | 1, 300 |
| 7 | 91 | 37 | 41 | 95 | 925 |
| Total | | | | 665 | 8, 344 |

*b. Uncrating and Unpacking Equipment Packed for Export Shipment.*

(1) Place the packing case as near the operating location as is convenient.

(2) Cut and fold back the steel straps.

(3) Remove the nails with a nail puller. Remove the top and the four sides of the packing case. Do not attempt to

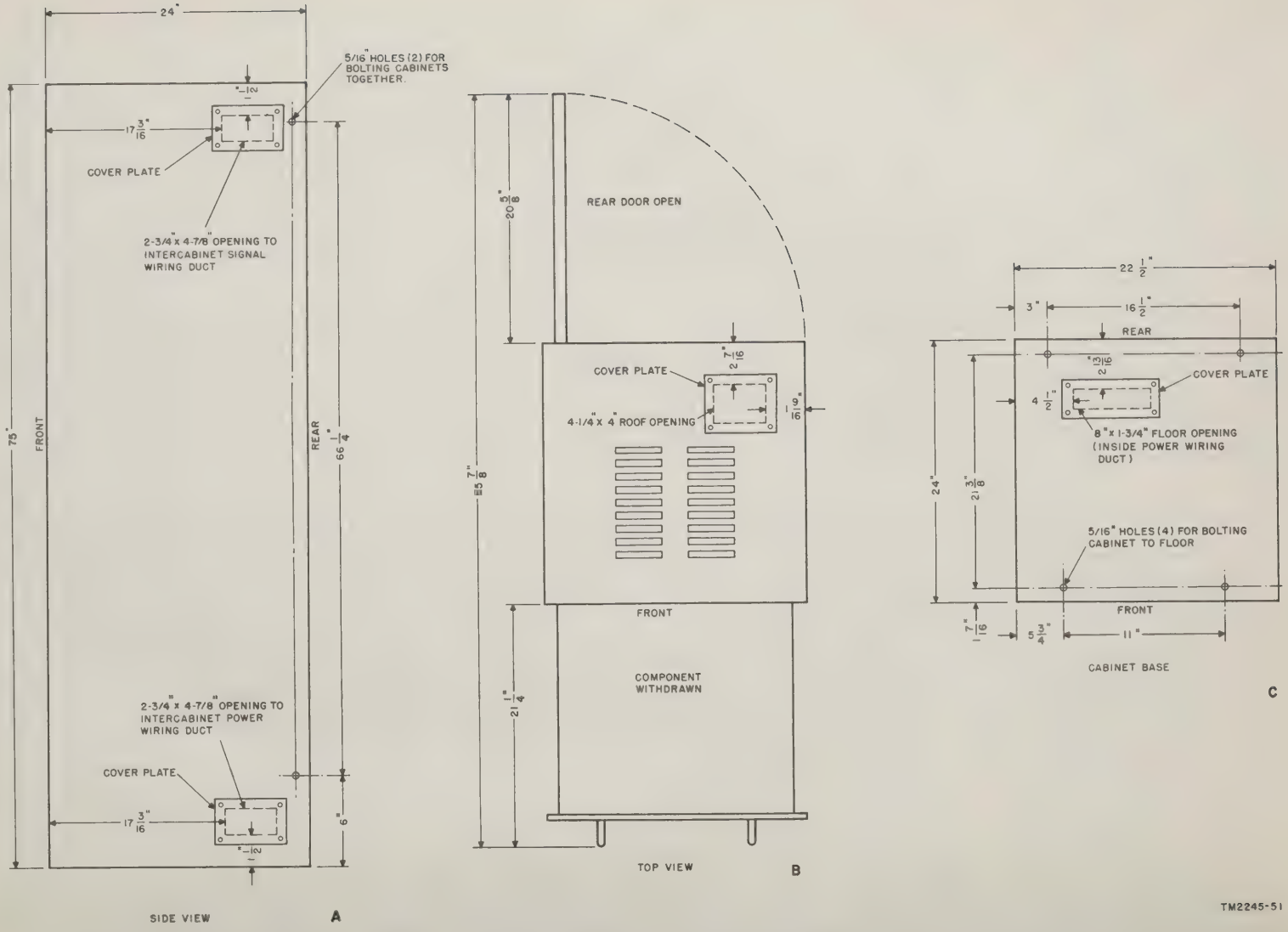



*Figure 19. Telegraph Terminal AN/FGC–29, cabinet outline and mounting dimension drawing.*

(2) *Contents of each shipping case.*

| Case No. | Dimensions (in.) | Contents | | Notes |
|---|---|---|---|---|
| | | Quantity | Item | |
| 1 | 91 x 37 x 41 | 1 | Cabinet 1 | Less loop battery supplies. |
| 2 | 91 x 37 x 41 | 1 | Cabinet 2 | Less voltage regulator. |
| 3 | 91 x 37 x 41 | 1 | Cabinet 3 | Less loop battery supplies. |
| 4 | 91 x 37 x 41 | 1 | Cabinet 4 | Less voltage regulator. |
| 5 | 91 x 37 x 41 | 1 | Cabinet 5 | |
| 6 | 91 x 37 x 41 | 1 | Cabinet 6 | Less voltage regulator. |
| 7 | 91 x 37 x 41 | 3 | Voltage regulators | |
| | | 4 | Loop battery supply | |
| | | 1 | RELAY PANEL | |
| | | 7 | DUMMY CIRCUIT PANEL | |
| | | 1 | Transformer assembly TF–206/FG | |
| | | 2 | Electrical Headset H–110/G | |
| | | 1 | Set of interconnecting cables and patching cords | |
| | | 1 | Set of running spares | |

pry off the top and sides or the equipment may become damaged.

(4) Open the outer corrugated cardboard carton and the moisture-vaporproof barrier. Remove the rubberized felt cushioning pads.

(5) Open the inner cardboard carton and remove the corrugated panels and supports from the inner carton.

(6) Remove the equipment from the inner carton and place it near its final location.

(7) Open the rear door of the cabinet. Use a screwdriver to remove the screws from the three horizontal supporting braces that are part of the metal supporting framework, which is used to prevent movement of the drawer panels during shipment. Remove the horizontal braces. Remove the bolts that hold the supporting framework to the drawer panels and to the cabinet; remove the supporting framework.

*c. Uncrating and Unpacking Equipment Packed or Domestic Shipment.* When cases are packed for domestic shipment, the moisture-vaporproof barrier is not used. For this type of shipment, uncrating and unpacking instructions are similar to those in *b* above.

*d. Checking and Inspecting.* Examine the equipment immediately after it is uncrated. Follow the procedures in (1) through (5) below:

(1) Check the contents of each packing case against its master packing slip.

(2) Inspect the cabinets for any physical damage that might have occurred during shipment.

(3) Check cable assemblies, patching cords, and power leads to make sure that they are in good condition.

(4) Check to see that the meters, fuses, and indicator lamps located on the front panels are undamaged. Check the controls for ease of operation.

(5) Check the accessories and running spares for possible damage.

## 47. Installation of Cabinets

Installation of the cabinets of Telegraph Terminal AN/FGC–29 consists of placing the equipment in its permanent location and installing the voltage regulators and loop battery supplies in their appropriate cabinets. The voltage regulators and loop battery supplies are shipped in the case with the accessories and running spares. To install the cabinets follow the procedures in *a* through *h* below:

*a.* Before placing the cabinets in position, remove the cover plates of the intercabinet signal and power wiring ducts (A, fig. 19) from all cabinets, except those which will be positioned at the ends of the cabinet lineup. From the end cabinets, remove only the cover plates located on the sides facing the lineup.

*b.* The preferred arrangement of cabinets is a consecutive lineup with cabinet 1 on the left and cabinet 6 on the right as viewed from the front (fig. 1). The cabinet number is marked on a

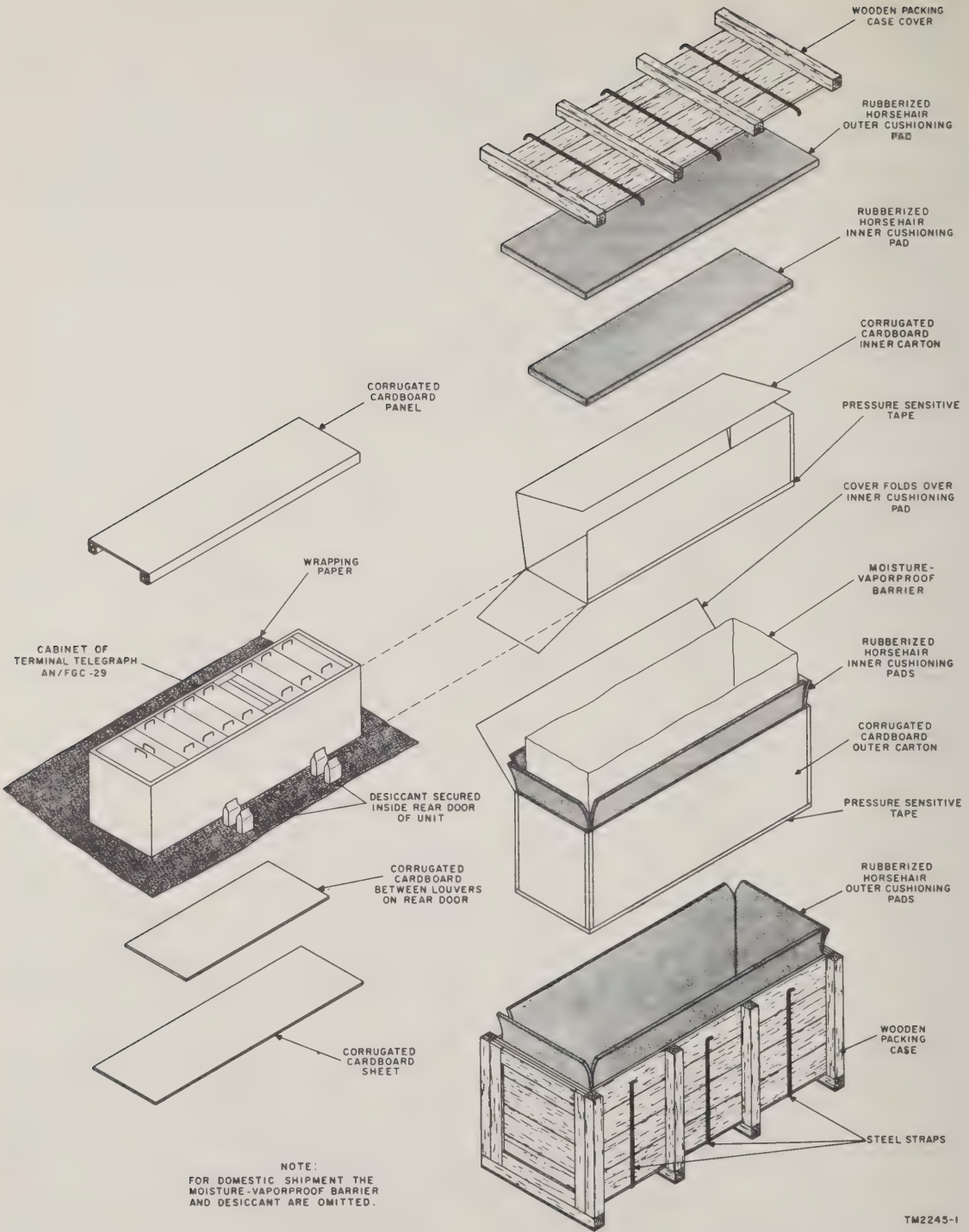

WOODEN PACKING CASE COVER
RUBBERIZED HORSEHAIR OUTER CUSHIONING PAD
RUBBERIZED HORSEHAIR INNER CUSHIONING PAD
CORRUGATED CARDBOARD INNER CARTON
CORRUGATED CARDBOARD PANEL
PRESSURE SENSITIVE TAPE
COVER FOLDS OVER INNER CUSHIONING PAD
WRAPPING PAPER
MOISTURE-VAPORPROOF BARRIER
CABINET OF TERMINAL TELEGRAPH AN/FGC-29
RUBBERIZED HORSEHAIR INNER CUSHIONING PADS
CORRUGATED CARDBOARD OUTER CARTON
DESICCANT SECURED INSIDE REAR DOOR OF UNIT
PRESSURE SENSITIVE TAPE
CORRUGATED CARDBOARD BETWEEN LOUVERS ON REAR DOOR
RUBBERIZED HORSEHAIR OUTER CUSHIONING PADS
WOODEN PACKING CASE
CORRUGATED CARDBOARD SHEET
STEEL STRAPS
NOTE:
FOR DOMESTIC SHIPMENT THE MOISTURE-VAPORPROOF BARRIER AND DESICCANT ARE OMITTED.
TM2245-1

*Figure 20. Telegraph Terminal AN/FGC–29, packing and packaging drawing.*

name plate in the upper left hand corner of each cabinet. The transmitting terminal (cabinets 1 and 2) and receiving terminal (cabinets 3–6) are independent of each other and, therefore, can be located separately, when necessary.

*c.* If primary power is supplied through buried conduit, locate the cabinet or cabinets that are to receive the external power connections so that the floor openings of these cabinets are directly above the power outlets in the conduit.

*d.* Bolt the cabinets together; use ¼-inch bolts 2 inches long. Insert the bolts through the holes on the sides of the cabinets (A, fig. 19). If desired, bolt the cabinets to the floor with ¼-inch bolts of suitable length; use the four covered holes (1 in. diameter) in the internal floor of the cabinet (C, fig. 19). The cover plates for these holes are each held by two screws. Remove one of the screws, and swing the cover plate out of the way to expose the hole.

*e.* Remove the cover panels from the front of cabinets 1 and 3 (figs. 4 and 6) and place two loop battery supplies on the floor of each cabinet (fig. 170). Connect plugs P1 and P2 of the loop battery supply designated as RECTIFIER A to receptacles J2 and J4, respectively, of the loop battery panels, and plugs P1 and P2 of RECTIFIER B to receptacles J3 and J5, respectively (figs. 25–28). Replace the cover panels.

*f.* Remove the front cover panels from cabinets 2, 4, and 6 and place one voltage regulator on the floor in each cabinet, with the terminal board on the voltage regulator facing the front of the cabinet (fig. 168). Connect the four wires in the cable form, which emerges from the rigid conduit on the left side of these cabinets, to terminals 1, 2, 3, and 5 of terminal board TB1 as indicated in the chart below and in the wiring diagrams figures 263, 265, and 267.

| Wire color | Connect to terminal board TB1 terminals |
|---|---|
| WHT-BLU | 1 |
| WHT-GY-GY | 2 |
| WHT-GY-RED | 3 |
| BLACK | 5 |

*g.* Set the 50—60 cycle switch (B, fig. 74) of each voltage regulator in the position that corresponds to the frequency of the power source. To do this, remove the switch guard, place the switch in the desired position, and replace the switch guard. The switch guard is fastened at one end by a screw. Mounting holes are provided near both switch positions so that the switch guard may be reversed and used in either position.

*h.* Replace the cover panels on the front of cabinets 2, 4, and 6.

## 48. Optional Location of Multiplexers TD–97/FGT–2, Demultiplexers TD–98/FGR–3, and Audio Frequency Amplifiers AM–911/FG

The location of the multiplexers, demultiplexers, and audio frequency amplifiers depends on the type of interconnecting line facilities used between the AN/FGC–29 terminal and the radio transmitter or radio receiver sites. For some applications, multiplexers, demultiplexers, or audio frequency amplifiers remain in the cabinets of the AN/FGC–29 terminal, and for other applications they are installed at the remote radio sites. Instructions for operating the drawer slides to remove and replace these components are given in paragraph 58. Instructions for installing drawer slides and components at the radio sites are given in TM 11–2265. The location of these components for 6-kc line operation is described in *a* below and for 3-kc line operation in *b* below.

*a. Location for Operation Over 6-kc Lines.*

(1) *Transmitting terminal.* The use of 6-kc line facilities between the transmitting terminal and the radio transmitter site is described in paragraph 40 and illustrated in figure 13. For this application arrange the panel components in cabinet 1 of the AN/FGC–29 terminal as indicated in A, figure 21, and install one audio frequency amplifier in a cabinet at the radio transmitter site as indicated in B, figure 21.

(2) *Receiving terminal.* The use of 6-kc line facilities between the receiving terminal and the radio receiver site is described in paragraph 40 and illustrated in figures 14 and 15. For this application, arrange the panel components in cabinet 3 of the AN/FGC–29 terminal as indicated in figure 22.

*b. Location for Operation Over 3-kc Lines.*

(1) *Transmitting terminal.* The use of 3-kc line facilities between the transmitting terminal and the radio transmitter site is

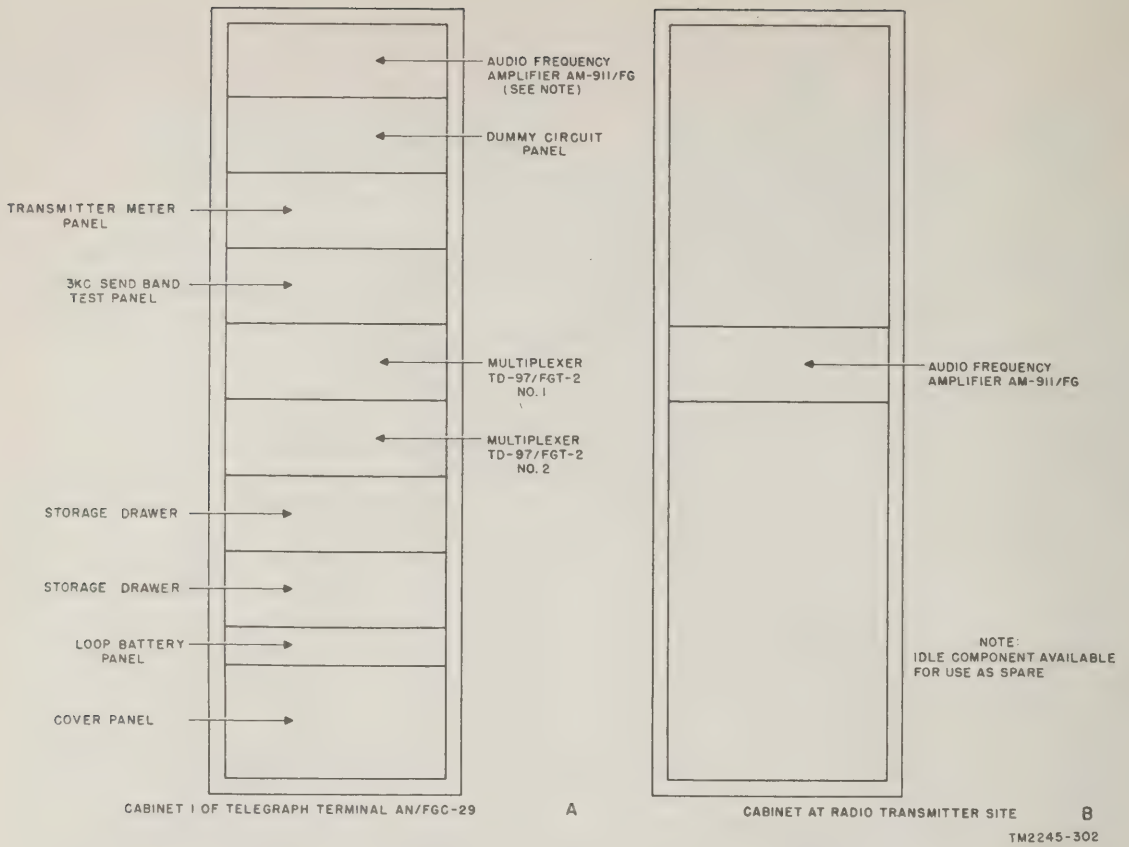



*Figure 21. Cabinet 1, panel locations for operation over 6-kc lines.*

described in paragraph 41 and illustrated in figure 16. For this application, arrange the panel components in cabinet 1 of the AN/FGC–29 terminal as indicated in A, figure 23 and install two multiplexers and two audio frequency amplifiers at the radio transmitter site as indicated in B, figure 23.

(2) *Receiving terminal.* The use of 3-kc facilities between the receiving terminal and the radio receiver site is described in paragraph 41 and is illustrated in figures 17 and 18. For this application, arrange the panel components in cabinet 3 of the AN/FGC–29 terminal as indicated in A, figure 24, and install three demultiplexers at the radio receiver site as indicated in B, figure 24. If required, install one Transformer Assembly TF–206/FG at the radio receiver site to match the impedance of lines not equipped with impedance matching transformers.

## 49. Cabinet Cording

Signal and power connections are made to each component by means of cables and plugs permanently affixed at one end to signal and power wiring ducts in each cabinet. A signal wiring duct is located on the right side of each cabinet (viewed from the rear) and a power wiring duct on the left side. Signal connectors from the signal wiring duct connect to signal receptacles on the right side of each component at the rear, and power connectors from the power wiring duct connect to power receptacles on the left side of each component. The equipment is shipped with the cabinet signal and power connectors in place. After arranging the components in cabinets 1 and 3 (par. 48), mate the signal and power connectors in these cabinets to their appropriate receptacles as described in *a* and *b* below. Check the cording

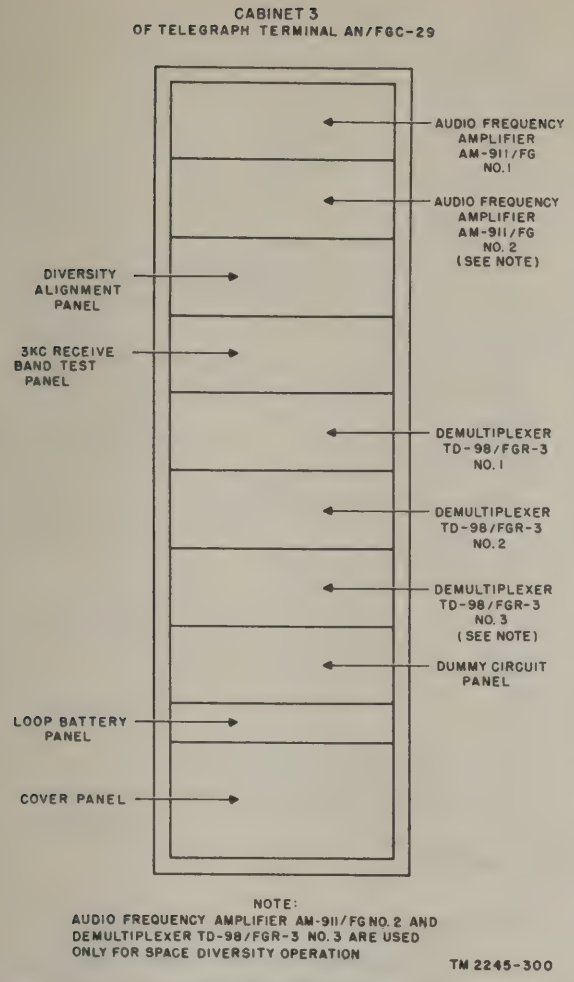

CABINET 3
OF TELEGRAPH TERMINAL AN/FGC-29
AUDIO FREQUENCY AMPLIFIER AM-911/FG NO. 1
AUDIO FREQUENCY AMPLIFIER AM-911/FG NO. 2 (SEE NOTE)
DIVERSITY ALIGNMENT PANEL
3KC RECEIVE BAND TEST PANEL
DEMULTIPLEXER TD-98/FGR-3 NO. 1
DEMULTIPLEXER TD-98/FGR-3 NO. 2
DEMULTIPLEXER TD-98/FGR-3 NO. 3 (SEE NOTE)
DUMMY CIRCUIT PANEL
LOOP BATTERY PANEL
COVER PANEL
NOTE:
AUDIO FREQUENCY AMPLIFIER AM-911/FG NO. 2 AND DEMULTIPLEXER TD-98/FGR-3 NO. 3 ARE USED ONLY FOR SPACE DIVERSITY OPERATION
TM 2245-300

*Figure 22. Cabinet 3, panel locations for operation over 6-kc lines.*

connections in cabinets 2, 4, 5, and 6 (figs. 29–32).

*a. Cording Connections for 6-Kc Operation.* When 6-kc line facilities are used, make the cording connections for the transmitting and receiving terminals as described in (1) and (2) below.

(1) *Transmitting terminal.* When the components in cabinet 1 are arranged for 6-kc operation (fig. 21), make the cording connections indicated in figure 25.

(2) *Receiving terminal.* When the components in cabinet 3 are arranged for 6-kc operation (fig. 22), make the cording connections indicated in figure 26.

*b. Cording Connections for 3-Kc Operation.* When 3-kc line facilities are used, make the cording connections for the transmitting and receiving terminals as described in (1) and (2) below.

(1) *Transmitting terminal.* When the components in cabinet 1 are arranged for 3-kc operation (fig. 23), make the cording connections indicated in figure 27.

(2) *Receiving terminal.* When the components in cabinet 3 are arranged for 3-kc operation (fig. 24), make the cording connections indicated in figure 28.

## 50. Cabinet Interconnections

(fig. 11)

Seven identical cable assemblies W151 are furnished for signal interconnections between cabinets. Each consists of a short piece of 19-conductor cable with multicontact connectors P151 and P152 (female) on the ends. Wiring for the power interconnections between cabinets is furnished in the power terminal boxes of cabinets 2, 4, and 6. The power wiring is permanently fastened at one end and is long enough to reach terminal boards in adjacent cabinets. Before making power interconnections, remove the covers from all six power terminal boxes (figs. 162–167) and the top cover of the power wiring duct at the base of each cabinet. Make the signal and power interconnections described in *a* and *b* below.

*a. Transmitting Terminal* (fig. 33).

(1) *Signal interconnections.* Pass cable assembly W151 (No. 1) through the intercabinet signal wiring duct between cabinets 1 and 2.

(*a*) Mate plug P151 with receptacle J3 in cabinet 1.

(*b*) Mate plug P152 with receptacle J5 in cabinet 2.

(2) *Power interconnections.* Power wiring for cabinets 1 and 2 is coiled in the power terminal box of cabinet 2 and fastened at one end to terminal boards TB131 and TB132. Pass these wires through the intercabinet power wiring duct to cabinet 1 and make the connections indicated in figure 33.

*b. Receiving Terminal* (fig. 34).

(1) *Signal interconnections.* Before making the receiving terminal signal interconnections as instructed in (*a*) through (*c*) below, orient each pair of cable assemblies W151 so that the male plug of one assembly is at the same end as the female plug of the second assembly.

(*a*) Pass cable assemblies W151 (Nos. 2 and 3) through the intercabinet signal

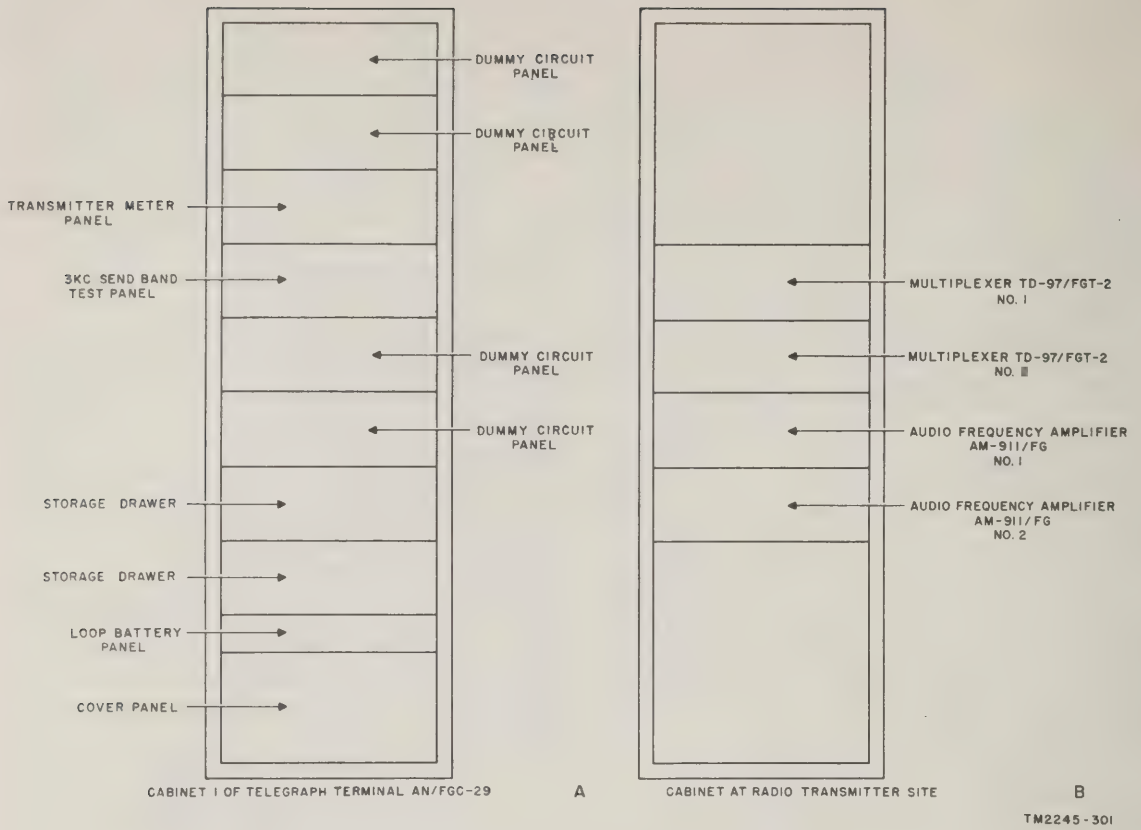



*Figure 23. Cabinet 1, panel locations for operation over 3-kc lines.*

wiring duct between cabinets 3 and 4.

*1.* Mate plug P152, of cable assembly W151 (No. 2), with receptacle J2 in cabinet 3 and mate plug P151 with receptacle J4 in cabinet 4.

*2.* Mate plug P151, of cable assembly W151 (No. 3), with receptacle J3 in cabinet 3 and mate plug P152 with receptacle J5 in cabinet 4.

(*b*) Pass cable assemblies W151 (Nos. 4 and 5) through the intercabinet signal wiring duct between cabinets 4 and 5.

*1.* Mate plug P152, of cable assembly W151 (No. 4), with receptacle J2 in cabinet 4, and mate plug P151 with receptacle J4 in cabinet 5.

*2.* Mate plug P151, of cable assembly W151 (No. 5), with receptacle J3 in cabinet 4 and mate plug P152 with receptacle J5 in cabinet 5.

(*c*) Pass cable assemblies W151 (Nos. 6 and 7) through the intercabinet signal wiring duct between cabinets 5 and 6.

*1.* Mate plug P152, of cable assembly W151 (No. 6), with receptacle J2 in cabinet 5 and mate plug P151 with receptacle J4 in cabinet 6.

*2.* Mate plug P151, of cable assembly W151 (No. 7), with receptacle J3 in cabinet 5 and mate plug P152 with receptacle J5 in cabinet 6.

(2) *Power interconnections* (fig. 34). Power wiring is coiled in the power terminal boxes of cabinets 4 and 6 and fastened at one end to terminal boards TB131 through TB133. Route the wires from cabinets 4 and 6 through the intercabinet power wiring ducts and make the connections indicated in figure 34.

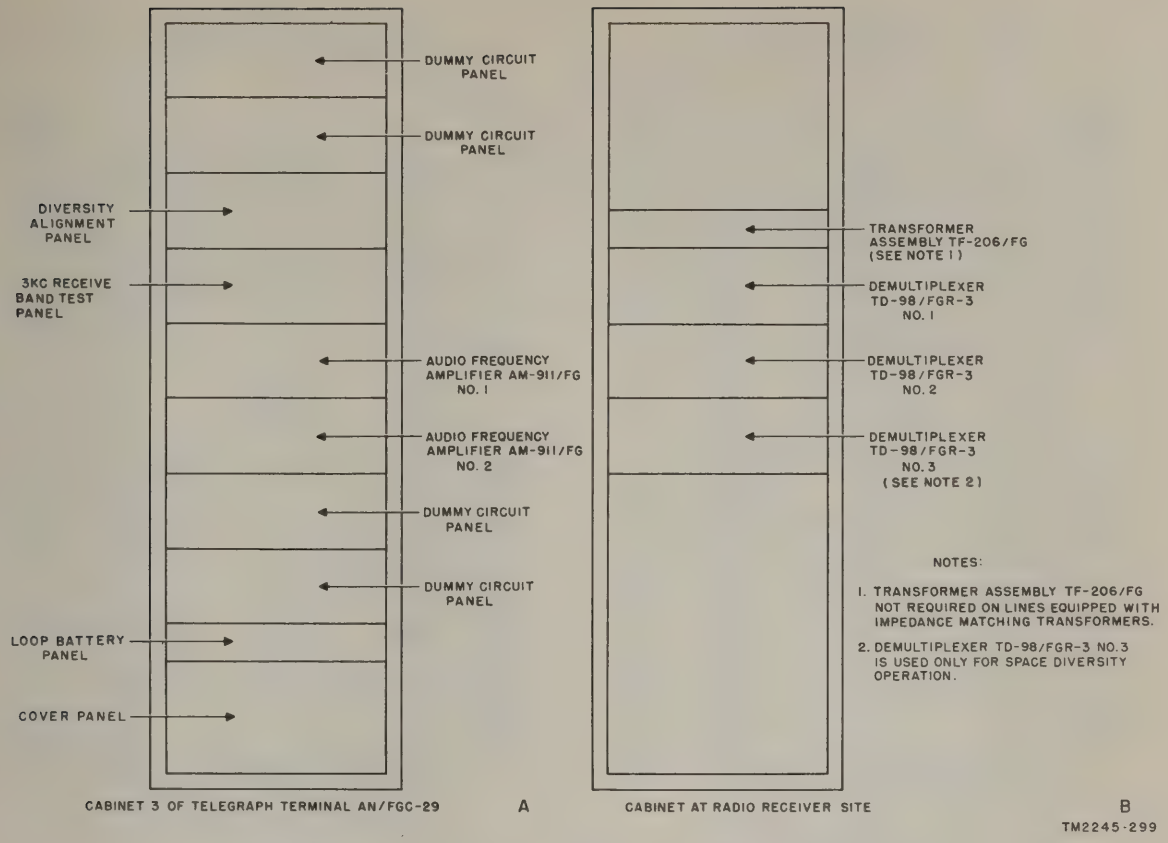

DUMMY CIRCUIT PANEL
DUMMY CIRCUIT PANEL
DIVERSITY ALIGNMENT PANEL
3KC RECEIVE BAND TEST PANEL
AUDIO FREQUENCY AMPLIFIER AM-911/FG NO. 1
AUDIO FREQUENCY AMPLIFIER AM-911/FG NO. 2
DUMMY CIRCUIT PANEL
DUMMY CIRCUIT PANEL
LOOP BATTERY PANEL
COVER PANEL
CABINET 3 OF TELEGRAPH TERMINAL AN/FGC-29
A
TRANSFORMER ASSEMBLY TF-206/FG (SEE NOTE 1)
DEMULTIPLEXER TD-98/FGR-3 NO. 1
DEMULTIPLEXER TD-98/FGR-3 NO. 2
DEMULTIPLEXER TD-98/FGR-3 NO. 3 (SEE NOTE 2)
NOTES:
1. TRANSFORMER ASSEMBLY TF-206/FG NOT REQUIRED ON LINES EQUIPPED WITH IMPEDANCE MATCHING TRANSFORMERS.
2. DEMULTIPLEXER TD-98/FGR-3 NO. 3 IS USED ONLY FOR SPACE DIVERSITY OPERATION.
CABINET AT RADIO RECEIVER SITE
B
TM2245-299

*Figure 24. Cabinet 3, panel locations for operation over 3-kc lines.*

## 51. External Power and Ground Connections

(fig. 35)

Primary power for the transmitting terminal is brought into cabinet 1 and for the receiving terminal into cabinets 3 and 5. Ground connection for the transmitting terminal is made in cabinet 1 and for the receiving terminal in cabinet 3. Follow the instructions in *a* below for routing the power and ground wiring into the appropriate cabinets and the instructions in *b* below for making the connections. Provide a source of primary power at 107 to 122 or 210 to 250 volts, 50 or 60 cps, capable of supplying 4,500 watts (or three separate sources, each capable of supplying 1,500 watts).

*a. Routing of Power and Ground Wiring.* Primary power and ground wiring may be routed into cabinets, 1, 3, and 5 in one of three ways. They may be routed through the intercabinet power wiring duct from openings at either, or both, ends of the row of cabinets; they may be routed down through a cabinet roof opening; or up through a cabinet floor opening. The location and dimensions of the cabinet openings are indicated in figure 19.

(1) *Use of power wiring duct* (A, fig. 19).

(*a*) Provide suitable power conduit to reach the opening for the intercabinet power wiring duct at one end of the row of cabinets.

(*b*) Remove the duct cover plate and cut a hole of proper size into it to accommodate a conduit fitting.

(*c*) Provide a fitting appropriate for the conduit used.

(*d*) Replace the duct cover plate and connect the conduit to the fitting.

(*e*) Run the power and ground leads from the conduit through the duct and up into the power terminal boxes of cabinets 1, 3, and 5.

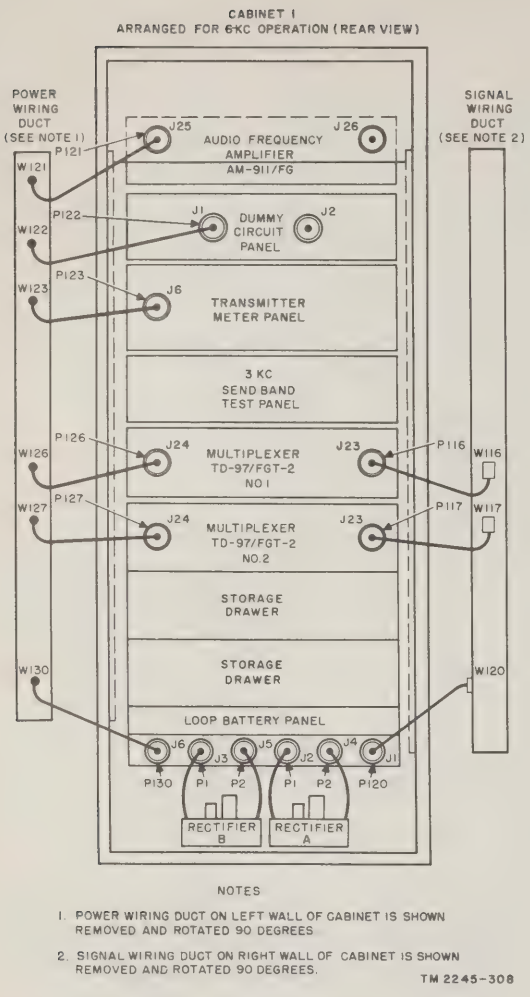

CABINET 1
ARRANGED FOR 6KC OPERATION (REAR VIEW)
POWER WIRING DUCT (SEE NOTE 1)
SIGNAL WIRING DUCT (SEE NOTE 2)
AUDIO FREQUENCY AMPLIFIER AM-911/FG
DUMMY CIRCUIT PANEL
TRANSMITTER METER PANEL
3 KC SEND BAND TEST PANEL
MULTIPLEXER TD-97/FGT-2 NO 1
MULTIPLEXER TD-97/FGT-2 NO.2
STORAGE DRAWER
STORAGE DRAWER
LOOP BATTERY PANEL
RECTIFIER B
RECTIFIER A
NOTES
1. POWER WIRING DUCT ON LEFT WALL OF CABINET IS SHOWN REMOVED AND ROTATED 90 DEGREES.
2. SIGNAL WIRING DUCT ON RIGHT WALL OF CABINET IS SHOWN REMOVED AND ROTATED 90 DEGREES.
TM 2245-308

*Figure 25. Cabinet 1, 6-kc operation, cording diagram.*

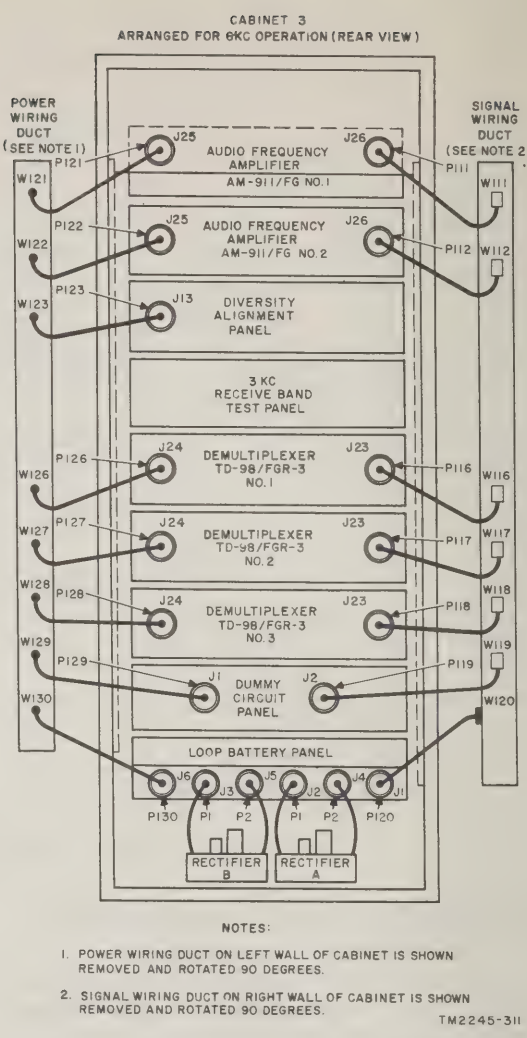

CABINET 3
ARRANGED FOR 6KC OPERATION (REAR VIEW)
POWER WIRING DUCT (SEE NOTE 1)
SIGNAL WIRING DUCT (SEE NOTE 2)
AUDIO FREQUENCY AMPLIFIER AM-911/FG NO.1
AUDIO FREQUENCY AMPLIFIER AM-911/FG NO.2
DIVERSITY ALIGNMENT PANEL
3 KC RECEIVE BAND TEST PANEL
DEMULTIPLEXER TD-98/FGR-3 NO.1
DEMULTIPLEXER TD-98/FGR-3 NO.2
DEMULTIPLEXER TD-98/FGR-3 NO.3
DUMMY CIRCUIT PANEL
LOOP BATTERY PANEL
RECTIFIER B
RECTIFIER A
NOTES:
1. POWER WIRING DUCT ON LEFT WALL OF CABINET IS SHOWN REMOVED AND ROTATED 90 DEGREES.
2. SIGNAL WIRING DUCT ON RIGHT WALL OF CABINET IS SHOWN REMOVED AND ROTATED 90 DEGREES.
TM2245-311

*Figure 26. Cabinet 3, 6-kc operation, cording diagram.*

(2) *Use of roof opening* (B, fig. 19).

(*a*) Provide suitable power conduit to reach the opening in the roof of a cabinet at one end of the row.

(*b*) Remove the cover plate and cut a hole of the proper size into it to accommodate a conduit fitting.

(*c*) Provide a fitting appropriate for the conduit used.

(*d*) Replace the cover plate and connect the conduit to the fitting.

(*e*) A knockout is located at the rear of the vertical power duct below the top of the duct. Remove this knockout and provide the hole with a suitable bushing.

(*f*) Run the power and ground leads from the conduit through the vertical power wiring duct into the horizontal intercabinet wiring duct in the cabinet base. From here, run the leads into the power terminal boxes of cabinets 1, 3, and 5.

(3) *Use of floor opening* (C, fig. 19).

(*a*) Provide suitable buried conduit to reach the opening in the base of the cabinet at one end of the row.

(*b*) Locate the cabinet so that this opening is directly above the point where the leads exit from the floor conduit.

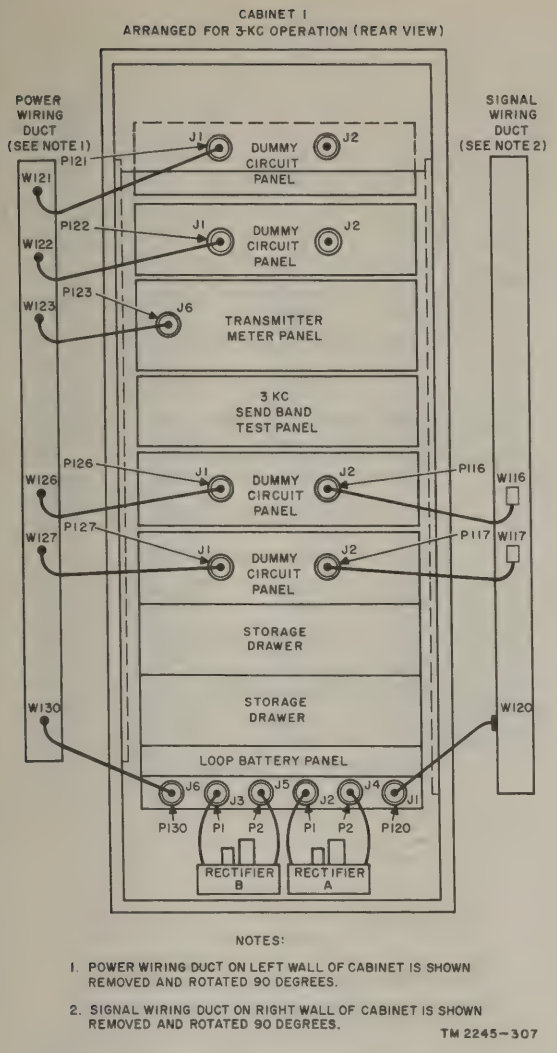



*Figure 27. Cabinet 1, 3-kc operation, cording diagram.*

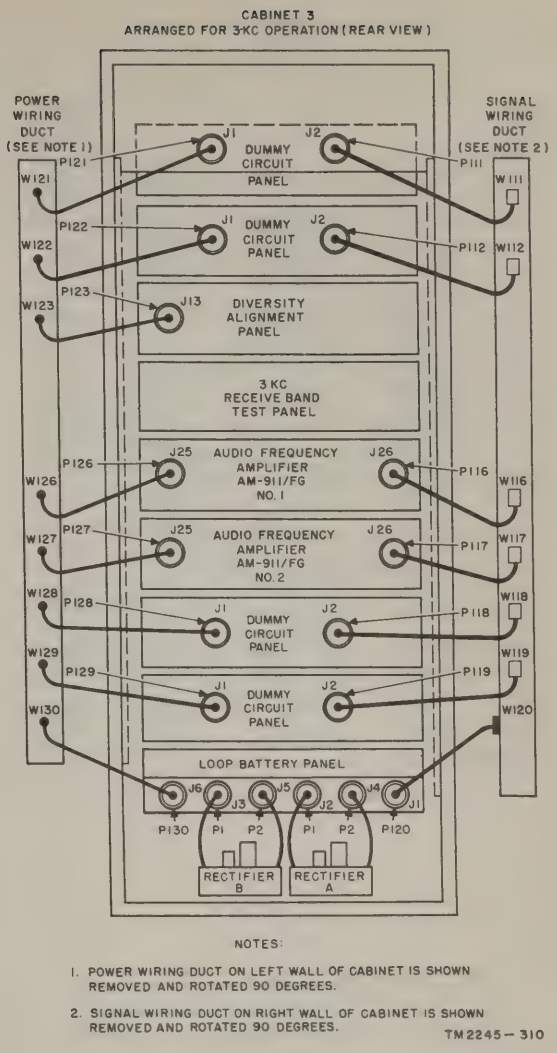



*Figure 28. Cabinet 3, 3-kc operation, cording diagram.*

(*c*) Remove the cover of the horizontal power wiring duct (fig. 162) to get at the cover plate of the floor opening in the base of the cabinet.

(*d*) Remove this cover and run the wires from the conduit up into the horizontal intercabinet wiring duct in the cabinet base. From here, run the leads into power terminal boxes of cabinets 1, 3, and 5.

(*e*) Replace the cover of the horizontal power wiring duct.

*b. Connections* (figs. 33 and 34).

(1) Connect the power source (or sources) to terminals 1 and 2 of TB131 in the power terminal boxes of cabinets 1, 3, and 5.

(2) Connect the station ground to terminal 4 of terminal boards TB131 in cabinets 1 and 3.

(3) Remove the cover from the main power unit in cabinets 1, 3, and 5 (figs. 162, 164, and 166).

(4) In each of these three cabinets, connect the lead from terminal 3 of switch S1 to

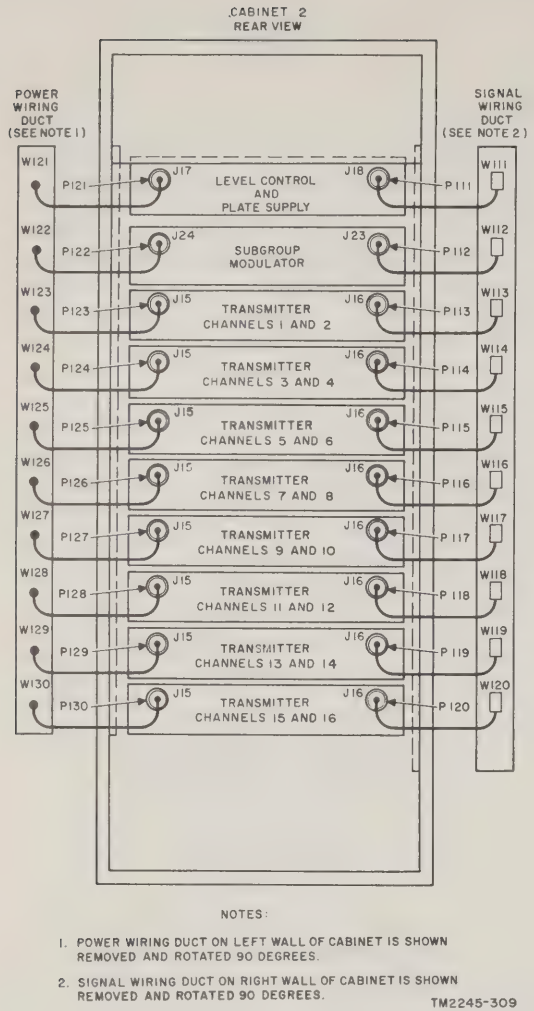

CABINET 2
REAR VIEW
POWER WIRING DUCT (SEE NOTE 1)
SIGNAL WIRING DUCT (SEE NOTE 2)
LEVEL CONTROL AND PLATE SUPPLY
SUBGROUP MODULATOR
TRANSMITTER CHANNELS 1 AND 2
TRANSMITTER CHANNELS 3 AND 4
TRANSMITTER CHANNELS 5 AND 6
TRANSMITTER CHANNELS 7 AND 8
TRANSMITTER CHANNELS 9 AND 10
TRANSMITTER CHANNELS 11 AND 12
TRANSMITTER CHANNELS 13 AND 14
TRANSMITTER CHANNELS 15 AND 16
NOTES:
1. POWER WIRING DUCT ON LEFT WALL OF CABINET IS SHOWN REMOVED AND ROTATED 90 DEGREES.
2. SIGNAL WIRING DUCT ON RIGHT WALL OF CABINET IS SHOWN REMOVED AND ROTATED 90 DEGREES.
TM2245-309

*Figure 29. Cabinet 2, cording diagram.*

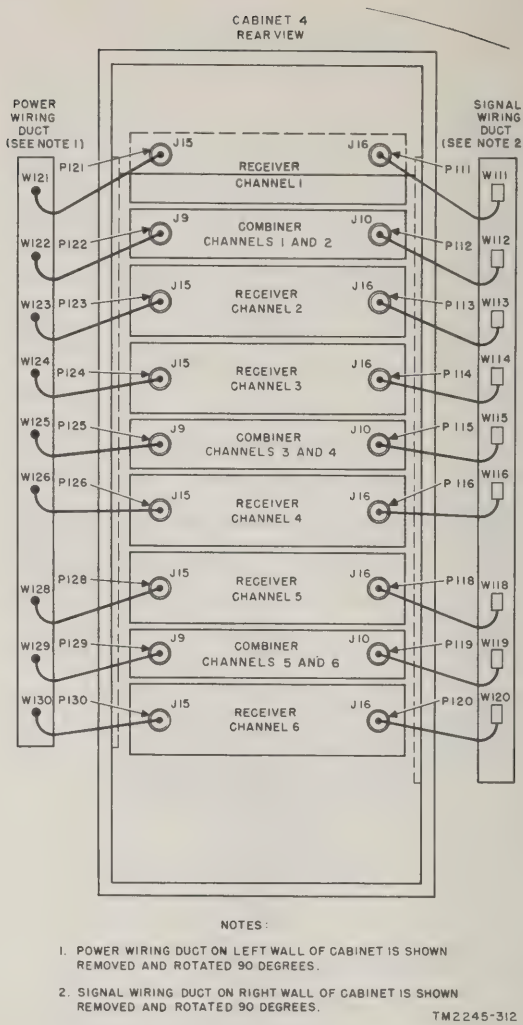

CABINET 4
REAR VIEW
POWER WIRING DUCT (SEE NOTE 1)
SIGNAL WIRING DUCT (SEE NOTE 2)
RECEIVER CHANNEL 1
COMBINER CHANNELS 1 AND 2
RECEIVER CHANNEL 2
RECEIVER CHANNEL 3
COMBINER CHANNELS 3 AND 4
RECEIVER CHANNEL 4
RECEIVER CHANNEL 5
COMBINER CHANNELS 5 AND 6
RECEIVER CHANNEL 6
NOTES:
1. POWER WIRING DUCT ON LEFT WALL OF CABINET IS SHOWN REMOVED AND ROTATED 90 DEGREES.
2. SIGNAL WIRING DUCT ON RIGHT WALL OF CABINET IS SHOWN REMOVED AND ROTATED 90 DEGREES.
TM2245-312

*Figure 30. Cabinet 4, cording diagram.*

the 107-, 115-, 122-, 210-, 230-, or 250-volt tap, whichever corresponds to the source voltage.

(5) Replace the cover on the main power units.

## 52. External Signal Connections

External signal connections for the AN/FGC–29 terminal are made to the transmitting terminal in cabinets 1 and 2, and to the receiving terminal in cabinets 3 and 6. All external signal connections are made by means of leads brought to screw-type terminals on terminal boards that are mounted horizontally across the top rear of the cabinet (figs. 162–167). The method of routing signal wiring into the cabinet and to the terminal boards is explained in *a* below. External signal connections for the transmitting terminal are explained in *b* below and for the receiving terminal in *c* below.

*a. Routing of Signal Wiring.* Signal wiring may be routed into the cabinets by way of the intercabinet signal wiring duct, the roof opening, or the floor opening.

(1) *Intercabinet signal wiring duct* (A, fig. 19).

(*a*) Run the signal wiring or cable to the opening for the intercabinet signal wiring duct at either, or both, ends of the row of cabinets.

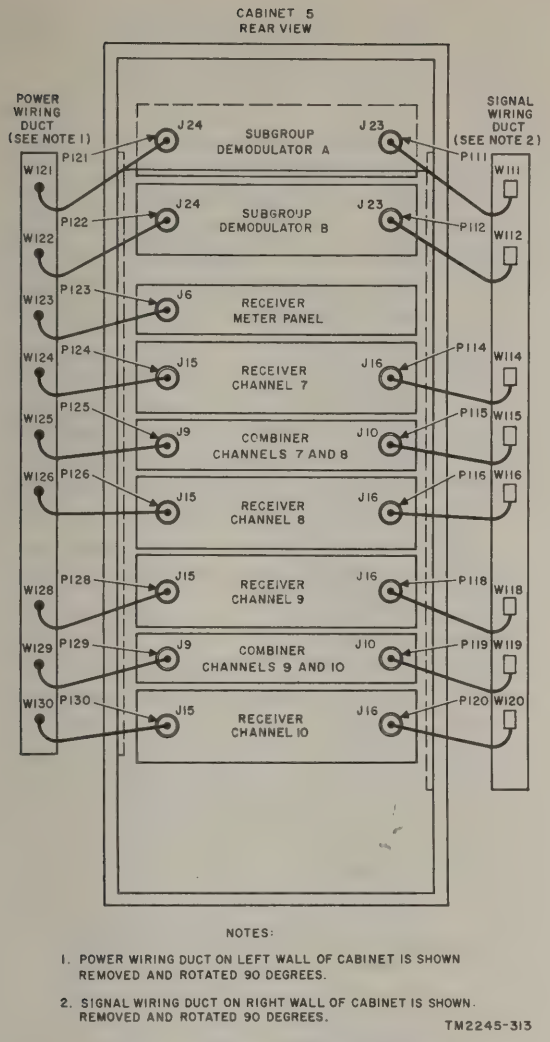

CABINET 5
REAR VIEW
POWER WIRING DUCT (SEE NOTE 1)
SIGNAL WIRING DUCT (SEE NOTE 2)
SUBGROUP DEMODULATOR A
SUBGROUP DEMODULATOR B
RECEIVER METER PANEL
RECEIVER CHANNEL 7
COMBINER CHANNELS 7 AND 8
RECEIVER CHANNEL 8
RECEIVER CHANNEL 9
COMBINER CHANNELS 9 AND 10
RECEIVER CHANNEL 10
NOTES:
1. POWER WIRING DUCT ON LEFT WALL OF CABINET IS SHOWN REMOVED AND ROTATED 90 DEGREES.
2. SIGNAL WIRING DUCT ON RIGHT WALL OF CABINET IS SHOWN REMOVED AND ROTATED 90 DEGREES.
TM2245-313

*Figure 31. Cabinet 5, cording diagram.*

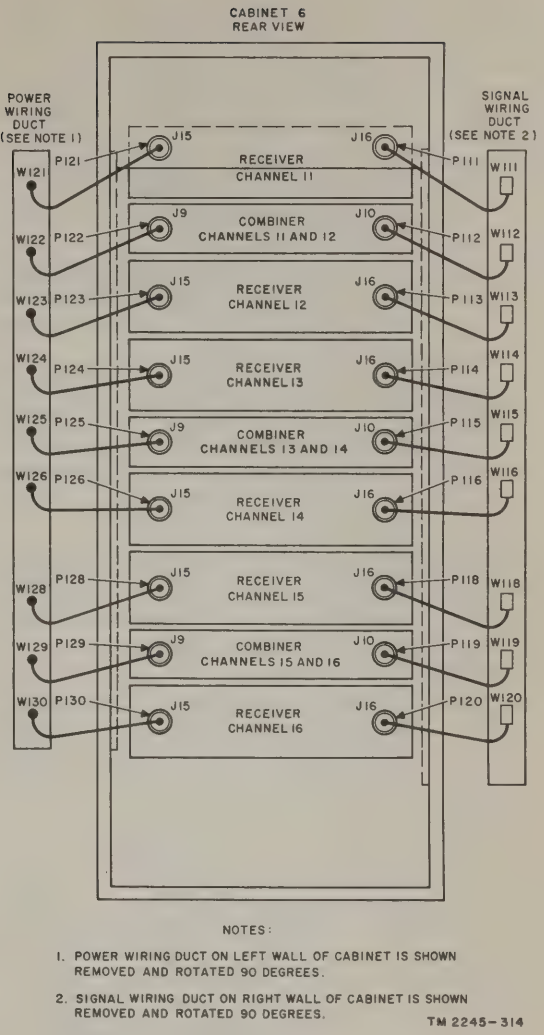

CABINET 6
REAR VIEW
POWER WIRING DUCT (SEE NOTE 1)
SIGNAL WIRING DUCT (SEE NOTE 2)
RECEIVER CHANNEL 11
COMBINER CHANNELS 11 AND 12
RECEIVER CHANNEL 12
RECEIVER CHANNEL 13
COMBINER CHANNELS 13 AND 14
RECEIVER CHANNEL 14
RECEIVER CHANNEL 15
COMBINER CHANNELS 15 AND 16
RECEIVER CHANNEL 16
NOTES:
1. POWER WIRING DUCT ON LEFT WALL OF CABINET IS SHOWN REMOVED AND ROTATED 90 DEGREES.
2. SIGNAL WIRING DUCT ON RIGHT WALL OF CABINET IS SHOWN REMOVED AND ROTATED 90 DEGREES.
TM 2245-314

*Figure 32. Cabinet 6, cording diagram.*

(*b*) Remove the duct cover plate. Cut a hole into it and provide a bushing of sufficient size to accommodate the wiring or cable.

(*c*) Replace the cover plate, pass the wiring through the hole, and run the connections through the intercabinet signal wiring duct directly to the terminal boards in the cabinets

(2) *Roof opening* (B, fig. 19).

(*a*) Run the signal wiring or cable to the opening in the cabinet roof.

(*b*) Remove the cover plate, cut a hole of suitable size and provide it with a bushing.

(*c*) Replace the cover plate and run the wiring through the bushing and the opening in the top of the intercabinet signal wiring duct directly to the terminal boards in the cabinets.

(3) *Floor opening* (C, fig. 19).

(*a*) Run the signal wiring or cable to the hole in the cabinet base.

(*b*) Remove the cover of the horizontal power wiring duct and the cover of the floor opening in the cabinet base.

(*c*) Cut a hole in the cover plate of the horizontal power wiring duct and provide it with a suitable bushing.

*Figure 33. Transmitting terminal, intercabinet cording diagram.*

(Contained in separate envelope)

*Figure 34. Receiving terminal, intercabinet cording diagram*

(Contained in separate envelope)

*Figure 35. Telegraph Terminal AN/FGC–29, primary power and ground connections.*

(Contained in separate envelope)

(*d*) Run the wiring through the hole and up the right side of the cabinet (viewed from the rear) to the terminal boards at the top.

(*e*) Fasten the wiring to the right side of the cabinet with cable clamps; use the 8–32 tapped holes that are located in a vertical row between the vertical signal wiring duct and the rear of the cabinet.

*b. Transmitting Terminal Connections* (fig. 36). Make the connections in (1) through (5) below to complete external signal and remote control connections for the transmitting terminal.

(1) *Input connections.*

(*a*) *Telegraph loops.* Connect the 16 transmitting telegraph loops to terminal boards in cabinet 2 as indicated in the chart below.

| Transmitting telegraph loop No. | Connect to | |
|---|---|---|
| | Terminals | Terminal board |
| 1 | 1 and 2 (GRD) | TB101 |
| 2 | 3 and 4 (GRD) | TB101 |
| 3 | 5 and 6 (GRD) | TB101 |
| 4 | 7 and 8 (GRD) | TB101 |
| 5 | 9 and 10 (GRD) | TB101 |
| 6 | 1 and 2 (GRD) | TB102 |
| 7 | 3 and 4 (GRD) | TB102 |
| 8 | 5 and 6 (GRD) | TB102 |
| 9 | 7 and 8 (GRD) | TB102 |
| 10 | 9 and 10 (GRD) | TB102 |
| 11 | 1 and 2 (GRD) | TB103 |
| 12 | 3 and 4 (GRD) | TB103 |
| 13 | 5 and 6 (GRD) | TB103 |
| 14 | 7 and 8 (GRD) | TB103 |
| 15 | 9 and 10 (GRD) | TB103 |
| 16 | 1 and 2 (GRD) | TB104 |

(*b*) *Telegraph.* The output of the telegraph transmitter group is connected to channel VF–1 by permanent wiring. *Do not* make any changes in the wiring to channel VF–1.

*Note.* VF–1, VF–2, VF–3, and VF–4 are designations assigned for identification of the four VF channels (or circuits) derived from twin-channel radios by the multiplexers and demultiplexers of the AN/FGC–29 terminal.

(*c*) *Telephone or facsimile.* Make connections to channels VF–2 through VF–4 on terminal board TB102 in cabinet 1 (fig. 36). Connect telephone or facsimile circuits to terminals 1 and 2 for VF–2, to terminals 3 and 4 for VF–3, and to terminals 5 and 6 for VF–4.

(2) *Output connections.*

(*a*) *6-kc facilities.* When 6-kc line facilities are used between the transmitting terminal and a remote radio transmitter site, two lines are required (fig. 13). Make line connections on terminal board TB101 in cabinet 1 (fig. 36). Connect line No. 1 to terminals 1 and 2 and connect line No. 2 to terminals 5 and 6.

(*b*) *3-kc facilities.*

*1. Line.* When 3-kc line facilities are used between the transmitting terminal and a remote radio transmitter site, four lines are required for space diversity operation and three lines are required for frequency diversity operation (fig. 16). Make line connections on terminal board TB101 in cabinet 1 (fig. 36). Connect line No. 1 to terminals 1 and 2, line No. 2 to terminals 3 and 4, line No. 3 to terminals 5 and 6, and line No. 4 to terminals 7 and 8.

*2. Radio relay or carrier telephone.* When 3-kc radio relay or carrier telephone circuits are used instead of 3-kc line facilities, connect each radio relay or carrier telephone circuit to terminal pairs on terminal board TB101 in cabinet 1, which correspond to the lines being replaced (*1* above).

(3) *Simplex connections.* Four simplex terminals, for dc signaling over interconnecting line facilities, are available on terminal board TB103 in cabinet 1. Simplexes 1 through 4 are associated with transformers T1 through T4, respectively, of Transformer Assembly TF–206/FG. If required, connect the

dc signaling equipment to terminal 1 for simplex 1, to terminal 2 for simplex 2, to terminal 3 for simplex 3, and to terminal 4 for simplex 4.

(4) *Trunk connections.* Terminals are available on terminal boards TB103 and TB104 of cabinet 1 for wiring eight general purpose trunk circuits to jacks on the 3KC SEND BAND TEST PANEL, for patching, monitoring, and testing purposes. Connect each trunk circuit as indicated in the chart below.

| Trunk circuit No. | Connect to | |
|---|---|---|
| | Terminal board | Terminals |
| 1 | TB103 | 5 and 6 |
| 2 | TB103 | 7 and 8 |
| 3 | TB103 | 9 and 10 |
| 4 | TB104 | 1 and 2 |
| 5 | TB104 | 3 and 4 |
| 6 | TB104 | 5 and 6 |
| 7 | TB104 | 7 and 8 |
| 9 | TB104 | 9 and 10 |

(5) *Remote control station connections.* Connect the control circuits from the remote control station to the terminal boards in cabinet 2, to provide remote control of the transmitters for 2-channel or 4-channel diversity operation. Make the connections indicated in the chart below.

| Remote control circuits for transmitter channels | Connect to— | |
|---|---|---|
| | Terminal board | Terminals |
| 1 and 2 | TB105 | 1 and 2 |
| 3 and 4 | TB105 | 3 and 4 |
| 5 and 6 | TB105 | 5 and 6 |
| 7 and 8 | TB105 | 7 and 8 |
| 9 and 10 | TB105 | 9 and 10 |
| 11 and 12 | TB106 | 1 and 2 |
| 13 and 14 | TB106 | 3 and 4 |
| 15 and 16 | TB106 | 5 and 6 |

*c. Receiving Terminal Connections* (fig. 37). Make the connections given in (1) through (5) below to complete the external signal and remote control connections for the receiving terminal.

(1) *Input connections.*

(*a*) *6-kc facilities.* When 6-kc line facilities are used between the receiving terminal and a remote radio receiver site, two lines are required for frequency diversity operation (fig. 15) and three lines are required for space diversity operation (fig. 14). Make line connections in cabinet 3 (fig. 37). Connect line No. 1 to terminals 9 and 10 of terminal board TB101. Connect line No. 2 to terminals 3 and 4 and line No. 3 to terminals 7 and 8 of terminal board TB102.

(*b*) *3-kc facilities.*

*1. Line.* When 3-kc line facilities are used between the receiving terminal and a remote radio receiver site, four lines are required for either space diversity operation (fig. 17) or frequency diversity operation (fig. 18). Make line connections in cabinet 3 (fig. 37). Connect line No. 1 to terminals 9 and 10 of terminal board TB101. Connect line No. 2 to terminals 1 and 2, line No. 3 to terminals 3 and 4, and line No. 4 to terminals 5 and 6 of terminal board TB102.

*2. Radio relay or carrier telephone.* When 3-kc radio relay or carrier telephone circuits are used instead of 3-kc line facilities, connect each radio relay or carrier telephone circuit to terminal pairs on terminal board TB101 or TB102 in cabinet 3, which correspond to the lines being replaced (*1* above).

(2) *Output connections.*

(*a*) *Telegraph loops.* Connect the 16 receiving telegraph loops to the terminal boards in cabinet 6 as indicated in the chart below.

| Receiving telegraph loop No. | Connect to | |
|---|---|---|
| | Terminal board | Terminals |
| 1 | TB101 | 1 and 2 (GRD) |
| 2 | TB101 | 3 and 4 (GRD) |
| 3 | TB101 | 5 and 6 (GRD) |
| 4 | TB101 | 7 and 8 (GRD) |
| 5 | TB101 | 9 and 10 (GRD) |
| 6 | TB102 | 1 and 2 (GRD) |
| 7 | TB102 | 3 and 4 (GRD) |
| 8 | TB102 | 5 and 6 (GRD) |
| 9 | TB102 | 7 and 8 (GRD) |

| Receiving telegraph loop No. | Connect to | |
|---|---|---|
| | Terminal board | Terminals |
| 10 | TB102 | 9 and 10 (GRD) |
| 11 | TB103 | 1 and 2 (GRD) |
| 12 | TB103 | 3 and 4 (GRD) |
| 13 | TB103 | 5 and 6 (GRD) |
| 14 | TB103 | 7 and 8 (GRD) |
| 15 | TB103 | 9 and 10 (GRD) |
| 16 | TB104 | 1 and 2 (GRD) |

(*b*) *Isolation of telegraph loops.* The AN/FGC–29 terminal furnishes only negative battery to ground to operate the receiving telegraph loops. Loops that have special battery requirements, other than —130 volts, must be isolated from the AN/FGC–29 terminal battery by relays. The RELAY PANEL furnished with the AN/FGC–29 terminal provides 16 relays for this purpose. The RELAY PANEL (fig. 10) divides each receiving telegraph loop into two parts: one part operates on the AN/FGC–29 terminal battery (driving loop); the other operates on its own local battery (driven loop). Install the RELAY PANEL in a suitable rack. Connect the driven loop to the RELAY PANEL as indicated in the table below. Connect the driving loop to the AN/FGC–29 terminal at the odd-numbered (negative) and even-numbered (ground) terminals as indicated in (*a*) above and to the RELAY PANEL as indicated in the chart below.

*Note.* To obtain the correct direction of current flow for the operation of the polar relays in the RELAY PANEL, connect the grounded side of the driving loops to the even-numbered terminals on the RELAY PANEL.

| Receiving loop | Connect driving loop to terminals | | Connect driven loop to— | |
|---|---|---|---|---|
| | Grd | Neg | Terminals | Terminal board |
| 1 | 2 | 1 | 3 and 4 | TB1 |
| 2 | 6 | 5 | 7 and 8 | TB1 |
| 3 | 10 | 9 | 11 and 12 | TB1 |
| 4 | 14 | 13 | 15 and 16 | TB1 |
| 5 | 2 | 1 | 3 and 4 | TB2 |
| 6 | 6 | 5 | 7 and 8 | TB2 |
| 7 | 10 | 9 | 11 and 12 | TB2 |
| 8 | 14 | 13 | 15 and 16 | TB2 |
| 9 | 2 | 1 | 3 and 4 | TB3 |
| 10 | 6 | 5 | 7 and 8 | TB3 |
| 11 | 10 | 9 | 11 and 12 | TB3 |
| 12 | 14 | 13 | 15 and 16 | TB3 |
| 13 | 2 | 1 | 3 and 4 | TB4 |
| 14 | 6 | 5 | 7 and 8 | TB4 |
| 15 | 10 | 9 | 11 and 12 | TB4 |
| 16 | 14 | 13 | 15 and 16 | TB4 |

(*c*) *Telegraph.* For 6-kc line operation, refer to the space and frequency diversity routing connections described in paragraphs 55 and 57 for the method of connecting the output of channel VF–1 to the input of the telegraph receiver group. For 3-kc line operation, connect terminals 1 and 2 to terminals 5 and 6 on terminal board TB107 in cabinet 3. Connect also terminals 3 and 4 to terminals 7 and 8 on this terminal board (fig. 37).

(*d*) *Telephone or facsimile.* For 6-kc line operation, refer to the space diversity and frequency diversity routing connections discussed in paragraphs 55 and 57. For 3-kc line operation, connect the telephone or facsimile circuit to terminals 9 and 10 of terminal board TB107, and terminals 1 and 2 of terminal board TB108 in cabinet 3.

(3) *Simplex connections.* Eight simplex terminals, for a maximum of eight lines (par. 59), are available on terminal board TB101 in cabinet 3. Simplexes 1 through 4 are associated with transformers T1 through T4, respectively, of Transformer Assembly TF–206/FG No. 1; simplexes 5 through 8 are associated with transformers T1 through T4, respectively, of Transformer Assembly TF–206/FG No. 2. If required, connect the dc signaling equipment as indicated in the chart below.

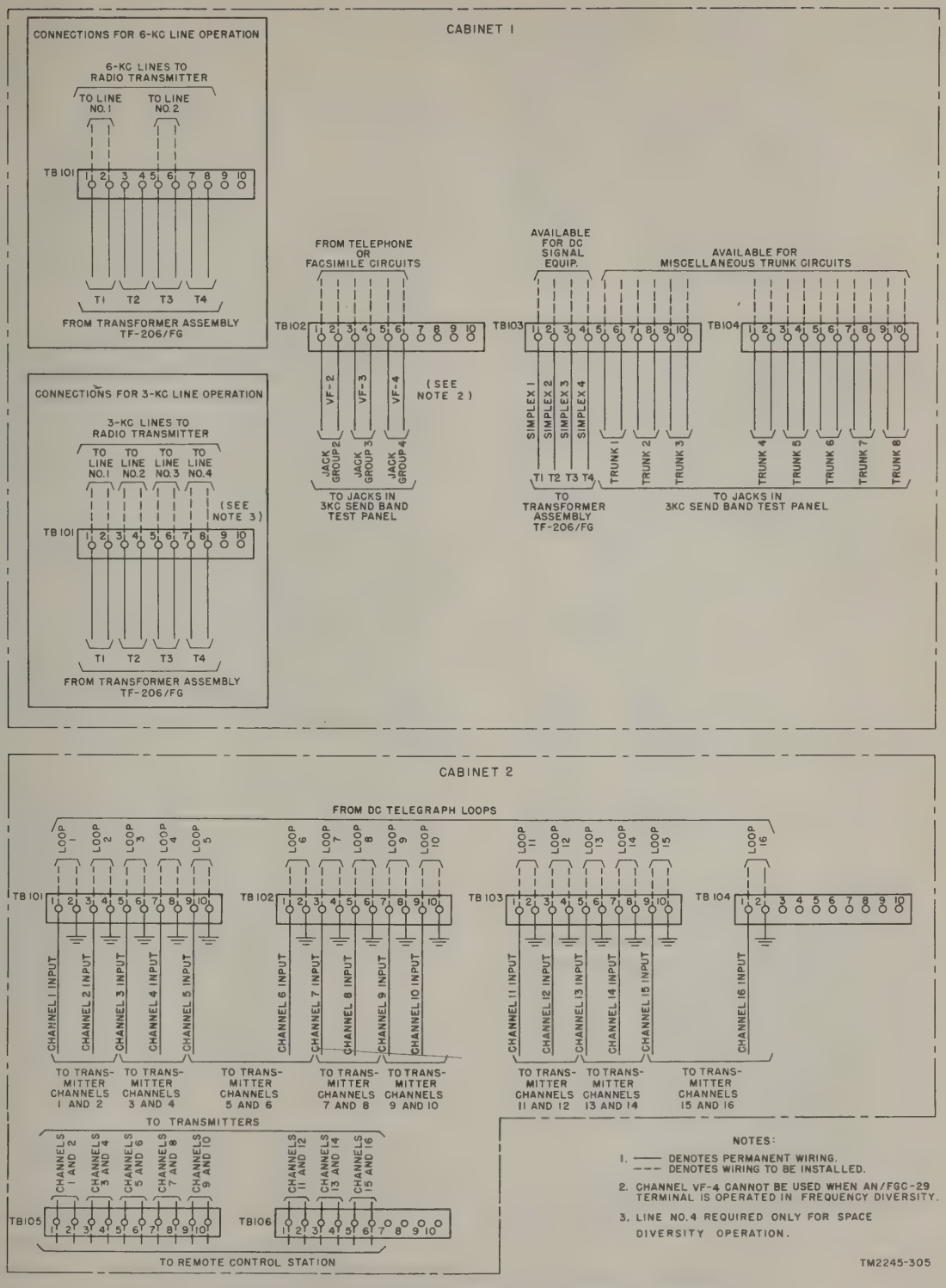



*Figure 36. Transmitting terminal, external signal connections.*

| Simplex circuit No. | Connect dc signaling equipment to— | |
|---|---|---|
| | Terminal | Terminal board |
| 1 | 1 | TB101 |
| 2 | 2 | TB101 |
| 3 | 3 | TB101 |
| 4 | 4 | TB101 |
| 5 | 5 | TB101 |
| 6 | 6 | TB101 |
| 7 | 7 | TB101 |
| 8 | 8 | TB101 |

(4) *Trunk connections.* Terminals are available on terminal boards TB103 and TB104 of cabinet 3 for wiring eight general purpose trunk circuits to jacks on the 3KC RECEIVE BAND TEST PANEL for patching, monitoring, and testing purposes. Connect each trunk circuit as indicated in the chart below and in figure 37.

| Trunk circuit No. | Connect to— | |
|---|---|---|
| | Terminal board | Terminals |
| 1 | TB103 | 5 and 6 |
| 2 | TB103 | 7 and 8 |
| 3 | TB103 | 9 and 10 |
| 4 | TB104 | 1 and 2 |
| 5 | TB104 | 3 and 4 |
| 6 | TB104 | 5 and 6 |
| 7 | TB104 | 7 and 8 |
| 8 | TB104 | 9 and 10 |

(5) *Remote control station connections.* Connect the control circuits from the remote control station to terminal board TB104 in cabinet 4, terminal board TB105 in cabinet 5, and terminal board TB104 in cabinet 6, to provide remote control of the combiners for 2-channel or 4-channel diversity operation. Make the connection indicated in the chart below and in figure 37.

| Remote control circuits for combiner channels | Connect to— | | |
|---|---|---|---|
| | Terminal board | Terminals | Cabinet |
| 1 and 2 | TB104 | 1 and 2 | 4 |
| 3 and 4 | TB104 | 3 and 4 | 4 |
| 5 and 6 | TB104 | 5 and 6 | 4 |
| 7 and 8 | TB105 | 7 and 8 | 5 |
| 9 and 10 | TB105 | 9 and 10 | 5 |
| 11 and 12 | TB104 | 5 and 6 | 6 |
| 13 and 14 | TB104 | 7 and 8 | 6 |
| 15 and 16 | TB104 | 9 and 10 | 6 |

*Figure 37. Receiving terminal, external signal connections.*
(Contained in separate envelope)

## 53. Impedance Matching Connections

*a.* The impedance of the transmitting terminal and the receiving terminal must match the impedance of the lines with which they are used. This is done by arranging the strap connections on terminal boards TB1 of their associated Transformer Assemblies TF–206/FG. Use the terminating impedances listed for various types of lines (par. 42). For the transmitting terminal, arrange the straps on terminal board TB1 of Transformer Assembly TF–206/FG (located at the rear of cabinet 1) as indicated in the chart below. For the receiving terminal, arrange the straps on terminal boards TB1 of Transformer Assemblies TF–206/FG Nos. 1 and 2 (located at the rear of cabinet 3) as indicated in the chart below.

Transformer Assembly TF-206/FG, connections

| Transformer | Strap terminals to match line impedance | | |
|---|---|---|---|
| | 150 ohms | 600 ohms | 1,350 ohms |
| T1 | 24 to 21 | 24 to 23 | 24 to 27 |
| | 25 to 22 | 25 to 26 | 25 to 28 |
| T2 | 32 to 29 | 32 to 31 | 32 to 35 |
| | 33 to 30 | 33 to 34 | 33 to 36 |
| T3 | 40 to 37 | 40 to 39 | 40 to 43 |
| | 41 to 38 | 41 to 42 | 41 to 44 |
| T4 | 48 to 45 | 48 to 47 | 48 to 51 |
| | 49 to 46 | 49 to 50 | 49 to 52 |

*b.* Audio Frequency Amplifier AM–911/FG has internal impedance matching facilities which are not required when the audio frequency amplifier is installed as part of the AN/FGC–29 terminal. In this case, adjust the internal wiring of the audio frequency amplifier for an input impedance of 600 ohms by connecting terminals 7 and 9 to terminals 10 and 12, respectively, and terminals

15 and 17 to terminals 18 and 20, respectively, on terminal board TB3 of the audio frequency amplifier.

## 54. Space Diversity Routing Connections for Transmitting Terminals

(fig. 38)

*a. General.* When the carrier telegraph channels are operated in space diversity, the telegraph signals are routed through one of the four vf circuits provided by the multiplexers. The output of the telegraph transmitter group is applied to input 1 of multiplexer No. 1 for transmission over the vf circuit designated as channel VF–1. Channel VF–1 is then routed to either transmission path of either multiplexer, without altering the external connections, according to one of four different connection options afforded by the arrangement of strap connections on terminal board TB9 of each multiplexer. Telephone or facsimile circuits are applied to the remaining multiplexer inputs for transmission over the vf circuits designated as VF–2, VF–3, and VF–4. The routing options chosen for the telegraph signals in VF–1 determines the paths available for the internal routing of the telephone or facsimile signals in channels VF–2, VF–3, and VF–4.

*b. Three-Kc Line Facilities.* When 3-kc line facilities are used, the multiplexers are installed at the radio transmitter site, and the routing operations are performed at that point. For multiplexer routing connections, follow the instructions in TM 11–2265.

*c. Six-Kc Line Facilities.* When 6-kc line facilities are used, the multiplexers are installed as an integral part of the transmitting terminal. Select one of the space diversity options shown in figure 38 and described in (1) through (4) below. Make the corresponding strap connections.

(1) *Option A.* The telegraph signals in channel VF–1 occupy the direct path of multiplexer No. 1. Channel VF–2 occupies the translated path of this multiplexer, while channels VF–3 and VF–4 occupy the direct and translated paths of multiplexer No. 2. The routing of the vf channels for this option and the strap connections required to obtain the routing are shown in A, figure 38. Make the strap connections listed in the chart below.

| Strap connections on terminal boards TB9 | |
|---|---|
| Multiplexer No. 1 (terminals) | Multiplexer No. 2 (terminals) |
| 3 to 5 | 3 to 5 |
| 4 to 6 | 4 to 6 |
| 11 to 13 | 11 to 13 |
| 12 to 14 | 12 to 14 |

(2) *Option B.* The telegraph signals in channel VF–1 occupy the translated path of multiplexer No. 1. Channel VF–2 occupies the direct path of this multiplexer, while channels VF–3 and VF–4 occupy the direct and translated paths of multiplexer No. 2. The routing of the vf channels for this option and the strap connections required to obtain the routing are shown in B, figure 38. Make the strap connections listed in the chart below.

| Strap connections on terminal boards TB9 | |
|---|---|
| Multiplexer No. 1 (terminals) | Multiplexer No. 2 (terminals) |
| 3 to 13 | 3 to 5 |
| 4 to 14 | 4 to 6 |
| 11 to 5 | 11 to 13 |
| 12 to 6 | 12 to 14 |

(3) *Option C.* The telegraph signals in channel VF–1 occupy the direct path of multiplexer No. 2. Channel VF–2 occupies the direct path of multiplexer No. 1. Channels VF–3 and VF–4 occupy the translated paths of multiplexers Nos. 1 and 2, respectively. The routing of the vf channels for this option and the strap connections required to obtain the routing are shown in C, figure 38. Make the strap connections listed in the chart below.

| Strap connections on terminal boards TB9 | |
|---|---|
| Multiplexer No. 1 (terminals) | Multiplexer No. 2 (terminals) |
| 3 to 7 | 3 to 15 |
| 4 to 8 | 4 to 16 |
| 11 to 5 | 11 to 13 |
| 12 to 6 | 12 to 14 |
| 15 to 13 | 7 to 5 |
| 16 to 14 | 8 to 6 |

(4) *Option D.* The telegraph signals in channel VF–1 occupy the translated path of multiplexer No. 2. Channel VF–2 occupies the direct path of multiplexer No. 1, and channel VF–3 occupies the translated path of this multiplexer. Channel VF–4 occupies the direct path of multiplexer No. 2. The routing of the vf channels for this option and the strap connections required to obtain the routing are shown in D, figure 38. Make the strap connections listed in the chart below.

| Strap connections on terminal boards TB9 | |
|---|---|
| Multiplexer No. 1 (terminals) | Multiplexer No. 2 (terminals) |
| 3 to 7 | 3 to 15 |
| 4 to 8 | 4 to 16 |
| 11 to 5 | 11 to 5 |
| 12 to 6 | 12 to 6 |
| 15 to 13 | 7 to 13 |
| 16 to 14 | 8 to 14 |

*Figure 38. Transmitting terminal, space diversity routing diagram.*

(Contained in separate envelope)

## 55. Space Diversity Routing Connections for Receiving Terminals

(fig. 39)

*a. General.* When the carrier telegraph channels are operated in space diversity, the telegraph signals are received from one of the vf circuits derived from radio receiver No. 1 and also from one of the vf circuits of radio receiver No. 2. Channel VF–1, from which the telegraph signals are received, has two outputs to provide two separate sources of received signals for the telegraph receiver group. Telegraph signals received from one output of demultiplexer No. 1 or demultiplexer No. 2 are applied to the A path of the telegraph receiver group. Telegraph signals from one output of demultiplexer No. 3 are applied to the B path. Telephone or facsimile signals may be received at the three remaining output of demultiplexers Nos. 1 and 2 from channels VF–2, VF–3, and VF–4, each of which occupies one of the demultiplexer transmission paths. The vf channels appear at the demultiplexer outputs in one of four possible ways, determined by the routing option selected in the multiplexers at the other end of the system.

*b. Three-Kc Operation.* When 3-kc facilities are used, the demultiplexers are installed at the radio receiver site and the routing connections are made at that point. For demultiplexer routing connections, follow the instructions in TM 11–2265.

*c. Six-Kc Operation.* When 6-kc facilities are used, the demultiplexers are located in cabinet 3 as an integral part of the receiving terminal. Routing of the vf channels containing telegraph signals to the A path and B path circuits and of the remaining vf channels to telephone or facsimile equipment is accomplished by connecting these circuits to the terminal pairs of terminal boards TB107 and TB108 in cabinet 3 as shown in figure 39 and discussed in (1) through (4) below.

(1) *Option A.* The telegraph signals in channel VF–1 occupy the direct paths of demultiplexers Nos. 1 and 3. Channel VF–2 occupies the translated path of demultiplexer No. 1 while channels VF–3 and VF–4 occupy the direct and translated paths of demultiplexer No. 2. The routing of the vf channels for this option and the required external connections, listed in the chart below, are shown in A, figure 39.

| Channel circuit | Connect from— | Connect to— |
|---|---|---|
| VF–1 | TB107, terminals 1 and 2. | TB107, terminals 5 and 6. |
| | TB 107, terminals 3 and 4. | TB108, terminals 3 and 4. |
| VF–2 | Telephone or facsimile circuit. | TB107, terminals 7 and 8. |
| VF–3 | Telephone or facsimile circuit. | TB107, terminals 9 and 10. |
| VF–4 | Telephone or facsimile circuit. | TB108, terminals 1 and 2. |

(2) *Option B.* The telegraph signals in channel VF–1 occupy the translated paths in demultiplexers Nos. 1 and 3. Channel VF–2 occupies the direct path of demultiplexer No. 1, while channels VF–3 and VF–4 occupy the direct and translated path of demultiplexer No. 2. The routing of the vf channels for this option and the required external connections, listed in the chart below, are shown in B, figure 39.

| Channel circuit | Connect from— | Connect to— |
|---|---|---|
| VF–1 | TB107, terminals 1 and 2. | TB107, terminals 7 and 8. |
| | TB107, terminals 3 and 4. | TB108, terminals 5 and 6. |
| VF–2 | Telephone or facsimile circuit. | TB107, terminals 5 and 6. |
| VF–3 | Telephone or facsimile circuit. | TB107, terminals 9 and 10. |
| VF–4 | Telephone or facsimile circuit. | TB108, terminals 1 and 2. |

(3) *Option C.* The telegraph signals in channel VF–1 occupy the direct paths of demultiplexers Nos. 2 and No. 3. Channel VF–2 occupies the direct path and channel VF–3 the translated path of demultiplexer No. 1. Channel VF–4 occupies the translated path of demultiplexer No. 2. The routing of the vf channels for this option and the required external connections, listed in the chart below, are shown in C, figure 39.

| Channel circuit | Connect from— | Connect to— |
|---|---|---|
| VF–1 | TB107, terminals 1 and 2. | TB107, terminals 9 and 10. |
| | TB107, terminals 3 and 4. | TB108, terminals 3 and 4. |
| VF–2 | Telephone or facsimile circuit. | TB107, terminals 5 and 6. |
| VF–3 | Telephone or facsimile circuit. | TB107, terminals 7 and 8. |
| VF–4 | Telephone or facsimile circuit. | TB108, terminals 1 and 2. |

(4) *Option D.* The telegraph signals in channel VF–1 occupy the translated paths of demultiplexers Nos. 2 and 3. Channels VF–2 and VF–3 occupy the direct and translated paths of demultiplexer No. 1, while channel VF–4 occupies the direct path of demultiplexer No. 2. The routing of the vf channels for this option and the required external connections, listed in the chart below, are shown in D, figure 39.

| Channel circuit | Connect from— | Connect to— |
|---|---|---|
| VF–1 | TB107, terminals 1 and 2. | TB108, terminals 1 and 2. |
| | TB107, terminals 3 and 4. | TB108, terminals 5 and 6. |
| VF–1 | Telephone or facsimile circuit. | TB107, terminals 5 and 6. |
| VF–3 | Telephone or facsimile circuit. | TB107, terminals 7 and 8. |
| VF–4 | Telephone or facsimile circuit. | TB107, terminals 9 and 10. |

*Figure 39. Receiving terminal, space diversity routing diagram.*

(Contained in separate envelope)

## 56. Frequency Diversity Routing Connections for Transmitting Terminals

(fig. 40)

*a. General.* When the carrier telegraph channels are operated in frequency diversity, the telegraph signals are routed over two multiplexer transmission paths simultaneously. The telegraph circuit is applied to input 1 of multiplexer No. 1 for transmission over channel VF–1. Channel VF–1 is then routed internally to any two transmission paths without altering the external connections, according to one of six different options afforded by the arrangement of the strap connections on terminal board TB3 of each multiplexer. Telephone or facsimile circuits are applied to the remaining multiplexer inputs for transmission over channels VF–2 and VF–3. The routing option chosen for the telegraph signals in VF–1 determines the paths available for the internal routing of the telephone or facsimile signals in channels VF–2, VF–3, and VF–4.

*b. Three-Kc Line Facilities.* When 3-kc line facilities are used, the multiplexers are installed at the radio transmitter site, and the routing operations are performed at that point. Use the instructions given in TM 11–2265.

*c. Six-Kc Line Facilities.* When 6-kc line facilities are used, the multiplexers are installed

as integral parts of the transmitting terminal. Select one of the frequency diversity options shown in figure 40 and described in (1) through (6) below. Make the corresponding strap connections.

(1) *Option A.* The telegraph signals in channel VF–1 occupy the direct and translated paths of multiplexer No. 1. Channel VF–2 occupies the direct path and channel VF–3 the translated path in multiplexer No. 2. The routing of the vf channels for this option and the strap connections required to obtain this routing are shown in A, figure 40. Make the strap connections listed in the chart below.

| Strap connections on terminal boards TB9 | |
|---|---|
| Multiplexer No. 1 (terminals) | Multiplexer No. 2 (terminals) |
| 3 to 1 | 3 to 13 |
| 4 to 2 | 4 to 14 |
| 9 to 5 | 7 to 5 |
| 10 to 6 | 8 to 6 |
| 17 to 13 | |
| 18 to 14 | |
| 11 to 7 | |
| 12 to 8 | |

(2) *Option B.* The telegraph signals in channel VF–1 occupy the direct paths of multiplexers Nos. 1 and 2. Channels VF–2 and VF–3 occupy the translated paths in multiplexers Nos. 1 and 2. The routing of the vf channels for this option and the strap connections required to obtain this routing are shown in B, figure 40. Make the strap connections listed in the chart below.

| Strap connections on terminal board TB9 | |
|---|---|
| Multiplexer No. 1 (terminals) | Multiplexer No. 2 (terminals) |
| 3 to 1 | 3 to 13 |
| 4 to 2 | 4 to 14 |
| 9 to 5 | 7 to 5 |
| 10 to 6 | 8 to 6 |
| 17 to 7 | |
| 18 to 8 | |
| 11 to 13 | |
| 12 to 14 | |

(3) *Option C.* The telegraph signals in channel VF–1 occupy the direct path of multiplexer No. 1 and the translated path of multiplexer No. 2. Channel VF–2 occupies the translated path of multiplexer No. 1. Channel VF–3 occupies the direct path of multiplexer No. 2. The routing of the vf channels for this option and the strap connections required to obtain this routing are shown in C, figure 40. Make the strap connections listed in the chart below.

| Strap connections on terminal board TB9 | |
|---|---|
| Multiplexer No. 1 (terminals) | Multiplexer No. 2 (terminals) |
| 3 to 1 | 3 to 5 |
| 4 to 2 | 4 to 6 |
| 9 to 5 | 7 to 13 |
| 10 to 6 | 8 to 14 |
| 17 to 7 | |
| 18 to 8 | |
| 11 to 13 | |
| 12 to 14 | |

(4) *Option D.* The telegraph signals in channel VF–1 occupy the translated path in multiplexer No. 1 and the direct path in multiplexer No. 2. Channel VF–2 occupies the direct path in multiplexer No. 1 and channel VF–3 occupies the translated path in multiplexer No. 2. The routing of the vf channels for this option and the strap connections required to obtain this routing are shown in D, figure 40. Make the strap connections listed in the chart below.

| Strap connections on terminal board TB9 | |
|---|---|
| Multiplexer No. 1 (terminals) | Multiplexer No. 2 (terminals) |
| 3 to 1 | 3 to 13 |
| 4 to 2 | 4 to 14 |
| 9 to 7 | 7 to 5 |
| 10 to 8 | 8 to 6 |
| 17 to 13 | |
| 18 to 14 | |
| 11 to 5 | |
| 12 to 6 | |

(5) *Option E.* The telegraph signals in channel VF–1 occupy the translated paths in multiplexers No. 1 and 2. Channels VF–2 and VF–3 occupy the direct paths in multiplexers Nos. 1 and 2. The routing of the vf channels for this option and the strap connections required to obtain this routing are shown in E, figure 40. Make the strap connections listed in the chart below.

| Strap connections on terminal boards TB9 | |
|---|---|
| Multiplexer No. 1 (terminals) | Multiplexer No. 2 (terminals) |
| 3 to 1 | 3 to 5 |
| 4 to 2 | 4 to 6 |
| 9 to 7 | 7 to 13 |
| 10 to 8 | 8 to 14 |
| 17 to 13 | |
| 18 to 14 | |
| 11 to 3 | |
| 12 to 6 | |

(6) *Option F.* The telegraph signals in Channel VF–1 occupy the direct and translated paths of multiplexer No. 2. Channel VF–2 occupies the direct path and channel VF–3 the translated path in multiplexer No. 1. The routing of the vf channels for this option and the strap connections required to obtain this routing are shown in F, figure 40. Make the strap connections listed in the chart below.

| Strap connections on terminal boards TB9 | |
|---|---|
| Multiplexer No. 1 (terminals) | Multiplexer No. 2 (terminals) |
| 3 to 7 | 3 to 15 |
| 4 to 8 | 4 to 16 |
| 11 to 5 | 7 to 1 |
| 12 to 6 | 8 to 2 |
| 15 to 13 | 9 to 5 |
| 16 to 14 | 10 to 6 |
| | 17 to 13 |
| | 18 to 14 |

*Figure 40. Transmitting terminals, frequency diversity routing diagram.*

(Contained in separate envelope)

## 57. Frequency Diversity Routing Connections for Receiving Terminals

(fig. 41)

*a. General.* When the carrier telegraph channels are operated in frequency diversity, the telegraph signals are received from two of the four vf circuits derived from the radio receiver. The incoming signals are carried by channel VF–1, which has two outputs to provide two separate sources of received signals. Telegraph signals received from one output of the demultiplexers are applied to the A path of the telegraph receiver group and telegraph signals from a second output are applied to the B path. Telephone or facsimile signals may be received at the two remaining outputs of demultiplexers Nos. 1 and 2 from channels VF–2 and VF–3, each of which occupies one of the demultiplexer transmission paths. The vf channels appear at the demultiplexer outputs in one of four possible ways, determined by the routing option selected in the multiplexers at the other end of the system.

*b. Three-Kc Operation.* When 3-kc facilities are used, the demultiplexers are installed at the radio receiver site and the routing of the vf channels is accomplished by connecting these circuits to the demultiplexer outputs as described in TM 11–2265.

*c. Six-Kc Operation.* When 6-kc facilities are used, the demultiplexers are installed as an integral part of the receiving terminal. Routing of the vf channels to the A path and B path circuits of the telegraph receiver group and to telephone or facsimile circuits is accomplished by connecting these circuits to the appropriate channels at terminal boards TB107 and TB108 of cabinet 3 as shown in figure 41 and discussed in (1) through (6) below.

(1) *Option A.* The telegraph signals in channel VF–1 occupy the direct and translated paths of demultiplexer No. 1. Channel VF–2 occupies the direct path, and channel VF–3 occupies the translated path of demultiplexer No. 2. The routing of the vf channels for this option

and the external connections required to obtain this routing are shown in A, figure 41, and in the chart below.

| Channel | Connect from | Connect to |
|---|---|---|
| VF–1 | TB107, terminals 1 and 2. | TB107, terminals 5 and 6. |
| | TB107, terminals 3 and 4. | TB107, terminals 7 and 8. |
| VF–2 | Telephone or facsimile circuit. | TB107, terminals 9 and 10. |
| VF–3 | Telephone or facsimile circuit. | TB108, terminals 1 and 2. |

(2) *Option B.* The telegraph signals in channel VF–1 occupy the direct paths of demultiplexer Nos. 1 and 2. Channel VF–2 occupies the translated path of demultiplexer No. 1. Channel VF–3 occupies the translated path of demultiplexer No. 2. The routing of the vf channels for this option and the external connections required to obtain this routing are shown in B, figure 41, and in the chart below.

| Channel | Connect from | Connect to |
|---|---|---|
| VF–1 | TB107, terminals 1 and 2. | TB107, terminals 5 and 6. |
| | TB107, terminals 3 and 4. | TB107, terminals 9 and 10. |
| VF–2 | Telephone or facsmilie circuit. | TB107, terminals 7 and 8. |
| VF–3 | Telephone or facsimile circuit. | TB108, terminals 1 and 2. |

(3) *Option C.* The telegraph signals in channel VF–1 occupy the direct path of demultiplexer No. 1 and the translated path of demultiplexer No. 2. Channel VF–2 occupies the translated path of demultiplexer No. 1 and channel VF–3 occupies the direct path of demultiplexer No. 2. The routing of the vf channels for this option and the external connections required to obtain this routing are shown in C, figure 41, and in the chart below.

| Channel | Connect from | Connect to |
|---|---|---|
| VF–1 | TB107, terminals 1 and 2. | TB107, terminals 5 and 6. |
| | TB107, terminals 3 and 4. | TB108, terminals 1 and 2. |
| VF–2 | Telephone or facsimile circuit. | TB107, terminals 7 and 8. |
| VF–3 | Telephone or facsimile circuit. | TB107, terminals 9 and 10. |

(4) *Option D.* The telegraph signals in channel VF–1 occupy the translated path of demultiplexer No. 1 and the direct path of demultiplexer No. 2. Channel VF–2 occupies the direct path of demultiplexer No. 1 and channel VF–3 occupies the translated path of demultiplexer No. 2. The routing of the vf channels for this option and external connections required to obtain this routing are shown in D, figure 41 and in the chart below.

| Channel | Connect from | Connect to |
|---|---|---|
| VF–1 | TB107, terminals 1 and 2. | TB107, terminals 7 and 8. |
| | TB107, terminals 3 and 4. | TB107, terminals 9 and 10. |
| VF–2 | Telephone or facsimile circuit. | TB107, terminals 5 and 6. |
| VF–3 | Telephone or facsimile circuit. | TB108, terminals 1 and 2. |

(5) *Option E.* The telegraph signals in channel VF–1 occupy the translated paths of demultiplexers Nos. 1 and 2. Channels VF–2 and VF–3 occupy the direct paths of demultiplexers Nos. 1 and 2 respectively. The routing of the vf channels for this option and the external connections required to obtain

this routing are shown in E, figure 41 and in the chart below.

| Channel | Connect from | Connect to |
|---|---|---|
| VF–1 | TB107, terminals 1 and 2. | TB107, terminals 7 and 8. |
| | TB107, terminals 3 and 4. | TB108, terminals 1 and 2. |
| VF–2 | Telephone or facsimile circuit. | TB107, terminals 5 and 6. |
| VF–3 | Telephone or facsimile circuit. | TB107, terminals 9 and 10. |

(6) *Option F.* The telegraph signals in channel VF–1 occupy the direct and translated paths in demultiplexer No. 2. Channel VF–2 occupies the direct path and channel VF–3 the translated path in demultiplexer No. 1. The routing of the vf channel for this option and the external connections required to obtain this routing are shown in F, figure 41 and in the chart below.

| Channel | Connect from | Connect to |
|---|---|---|
| VF–1 | TB107, terminals 1 and 2. | TB107, terminals 9 and 10. |
| | TB107, terminals 3 and 4. | TB108, terminals 1 and 2. |
| VF–2 | Telephone or facsimile circuit. | TB107, terminals 5 and 6. |
| VF–3 | Telephone or facsimile circuit. | TB107, terminals 7 and 8. |

*Figure 41. Receiving terminal, frequency diversity routing diagram.*
(Contained in separate envelope)

## 58. Operation of Drawer Slides

Most of the components of the AN/FGC–29 terminal are mounted on drawer slides. The drawer slides permit the component to be partially withdrawn from the cabinet to give access to the top of the drawer-type chassis (fig. 42), and also to be swung into a position (past the vertical) to permit inspection and maintenance of the parts on the underside of the chassis (fig. 43). When multiplexers, demultiplexers, or audio frequency amplifiers are removed from the AN/FGC–29 terminal and installed at the radio transmitter or receiver site, the drawer slides for these components must be removed from the cabinet to accompany the equipment. Instructions for installing the drawer slides are given in TM 11–2265.

***Caution:*** Panels which are fastened to the cabinet members by slotted screws through their front panels are not on drawer slides. These panels must be supported when these screws are removed.

*a. Withdrawing Drawer-Type Components.* To withdraw a component from the cabinet for inspection, follow the instructions given in (1) through (8) below.

(1) Release the captive screws which secure the front panel to the cabinet (fig. 42).
(2) Grasp the front panel handles and pull the drawer forward as far as the limit pins will permit.
(3) When access to the underside of the chassis is required, grasp the handles and raise the front end of the drawer so that the equipment pivots on the pivot roller.
(4) Swing the drawer past the vertical until the thumb nut stud on the chassis engages the slotted catch on the roller slide.
(5) Tighten the thumb nut to prevent the drawer from accidentally swinging out of position.
(6) To inspect parts on the underside of the chassis, remove the perforated bottom cover (fig. 43). Grasp the cover by the two finger holes provided. Exert sufficient pull to free the snap-type studs from the sockets and slide the cover free from the positioning groove on the rear of the front panel.
(7) To replace the bottom cover, slide the unflanged edge into the positioning groove on the front panel, align the snap-studs with their respective sockets, and press the cover gently into place.
(8) To return the drawer to the cabinet, loosen the thumb nut enough to provide clearance for the catch. Swing the drawer forward to a horizontal position; be sure the cable is free from kinks and bends. Slide the drawer into the cabinet and tighten the captive screws on the front panel.

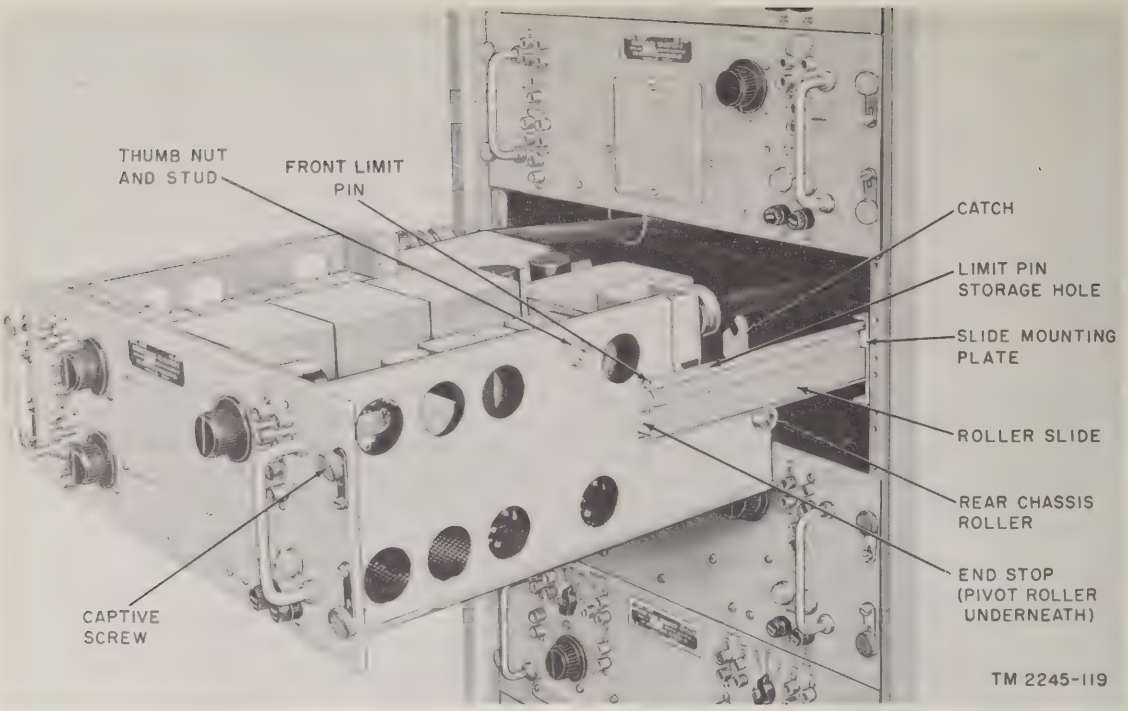



*Figure 42. Drawer-type chassis withdrawn from cabinet.*

*b. Removing Drawer-Type Components From Cabinet.* To remove a component completely from the cabinet, proceed as follows:

(1) Release the captive screws which secure the front panel to the cabinet (fig. 42).
(2) Pull the drawer forward as far as the limit pins will permit; use the front handles.
(3) Disconnect the cable assembly and power cord from their receptacles at the rear of the chassis.
(4) Remove the front limit pins on both sides and insert them in the storage holes.
(5) Grasp the equipment firmly by the handles and lift the pivot rollers over the end stops. The drawer will now come free.
(6) Push the roller slides back into the cabinet.
(7) When a component is removed permanently from the cabinet and is replaced by a DUMMY CIRCUIT PANEL, remove the drawer slides as well. Use a screw driver to take out the four screws that hold each slide mounting plate to the cabinet.

*c. Replacing Drawer-Type Component in Cabinet.* To replace a component in the cabinet, proceed as follows:

(1) Withdraw both roller slides from the cabinet until stopped by the rear limit pins.
(2) Grasp the drawer firmly and lift it (with the rear of the chassis lower than the front panel) until it is possible to ease the pivot rollers on the drawer over the end stops on the roller slides (fig. 42).
(3) Lower the drawer until the rear chassis rollers bear on the undersides of the roller slides.
(4) Place the limit pins in the front holes.
(5) Connect the cable assembly and power cord to the receptacles at the rear of the chassis. Be sure the cable is free of twists and kinks.

## 59. Installation of Additional Equipment

In space diversity reception over 3-kc lines, one of the four voice frequency circuits derived from the radio by the demultiplexers may be lost because the equipment to bring it through is not present. By adding additional equipment to

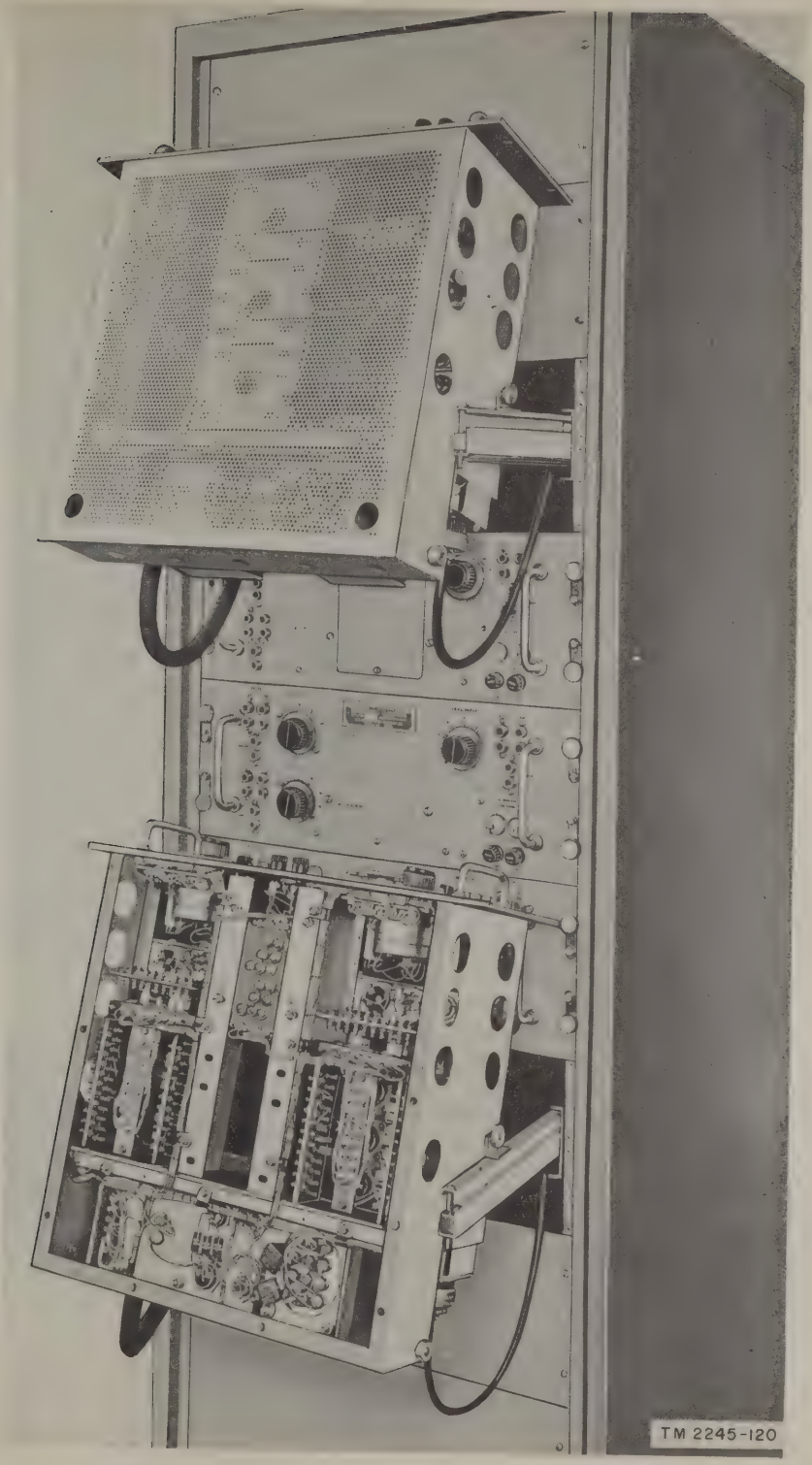



*Figure 43. Drawer-type chassis in position for maintenance.*

the basic AN/FGC–29 terminal, this vf circuit may be regained as explained in *a* below. Also, it is possible by adding additional equipment to bring out all four vf circuits from the diversity receiver (radio receiver No. 2) over 3-kc or 6-kc lines in the same manner as from radio receiver No. 1 (*b* and *c* below).

*a.* When the receiving terminal is installed for space diversity operation over 3-kc facilities, only three vf circuits can be handled with the complement of audio frequency amplifiers in the receiving terminal as shown in figure 17. The fourth vf channel (indicated as an unused facility in fig. 17) may be brought to the receiving terminal over 3-kc lines by adding an additional audio frequency amplifier to the receiving terminal. This additional amplifier may be the audio frequency amplifier from the transmitting terminal (indicated in fig. 13 as an unused component) when the transmitting terminal is operated over 6-kc line facilities. Install this amplifier in place of the DUMMY CIRCUIT PANEL immediately beneath audio frequency amplifier No. 2 in cabinet 3 shown in A, figure 24. Provide an additional 3-kc line (line No. 5), and impedance matching facilities (par. 42) for this line at the radio receiver site. At the receiving terminal connect line No. 5 to terminals 7 and 8 of terminal board TB102 in cabinet 3 (fig. 37). Connect the telephone or facsimile circuit to terminals 3 and 4 of terminal board TB108 in cabinet 3.

*b.* If, for any reason, it is desired to bring all four vf circuits from radio receiver No. 2 to the receiving terminal over 3-kc lines in the same manner as from radio receiver No. 1, add an additional demultiplexer (demultiplexer No. 4) to the installation at the radio receiver site, and two additional audio frequency amplifiers (audio frequency amplifiers Nos. 3 and 4) to the receiving terminal. Install demultiplexer No. 4 immediately beneath demultiplexer No. 3 in the cabinet at the radio receiver site (B, fig. 24) and audio frequency amplifiers Nos. 3 and 4 immediately beneath audio frequency amplifier No. 2 in cabinet 3 of the receiving terminal (A, fig. 24). Provide four additional 3-kc lines (lines Nos. 5–8), with appropriate impedance matching facilities to bring the diversity channels from the radio receiver. Use an additional Transformer Assembly TF–206/FG, which contains four transformers to match the four lines, or similar facilities which may be available. At the radio site, connect the output of the previously unused sideband of radio receiver No. 2 to the input of demultiplexer No. 4. At the receiving terminal, in cabinet 3, connect line No. 5 to terminal board TB102 at terminals 7 and 8 and line No. 6 at terminals 9 and 10; connect line No. 7 to terminal board TB103 at terminals 1 and 2, and line No. 8 at terminals 3 and 4; connect telephone or facsimile circuits to terminal board TB108 (fig. 37).

*c.* If it is desired to bring all four vf circuits from radio receiver No. 2 to the receiving terminal over 6-kc lines, install a fourth demultiplexer (demultiplexer No. 4) in the receiving terminal. Install demultiplexer No. 4 in place of the DUMMY CIRCUIT PANEL beneath demultiplexer No. 3 in cabinet 3 (fig. 22). Provide a fourth 6-kc line (line No. 4) to bring the output of sideband B of radio receiver No. 2 to the previously unused amplifier B of audio frequency amplifier No. 2. At the receiving terminal, in cabinet 3, connect line No. 4 to TB103 at terminals 1 and 2, and connect telephone or facsimile circuits to terminal board TB108 (fig. 37). Terminals on terminal board TB108 that will be available for connection to telephone or facsimile circuits will depend upon the routing connection option used for the telegraph channel (fig. 39).

## 60. Fuses

To replace any fuse, unscrew the fuse holder top and take out the blown fuse. Replace with the appropriate type from the list of fuses used in the AN/FGC–29 terminal in the chart below.

***Caution:*** Use the fuse of the proper rating and type. Do not use fuses rated above the specified value or of the wrong type. Damage to the equipment may result.

| Fuse panel marking | Reference designation | Rating | Location | Figure reference |
|---|---|---|---|---|
| LOOP FUSE | F1, F5 | *.1 amp | Transmitter | 44 |
| 200 V. D. C | F2 | 1/16 amp | | |
| AC POWER | F3, F4 | 3/8 amp | | |
| AC POWER | F1, F2 | *1 amp | SUBGROUP MODULATOR | 47 |
| 200 V. D. C | F1, F2 | 1/8 amp | LEVEL CONTROL & PLATE SUPPLY | 49 |
| 230 V. A. C | F3 through F6 | *1 amp | | |
| A. C. POWER | F1, F2 | *1 amp | Multiplexer | 58 |
| LOOP FUSES | F1 through F16 | 1/2 amp | LOOP BATTERY PANEL | 75 |
| INPUT FUSES | F19 through F22 | *3 amp | | |
| A. C. POWER | F1, F2 | *1/4 amp | TRANSMITTER METER PANEL | 66 |
| −130V | F3 | 1/8 amp | | |
| 10 AMP SLO | F3 | *10 amp | Main power unit | 72 |
| 20 AMP SLO | F4, F5 | *20 amp | | |
| 5 AMP SLOW | F1, F2 | *5 amp | Power panel | 244 |
| FUSE | F1 | 1 amp | Voltage regulator | 228 |
| A. C. POWER | F1, F2 | *1 amp | Audio frequency amplifier | 61 |
| A. C. POWER | F1, F2 | *1 amp | Demultiplexer | 63 |
| A. C. POWER | F1, F2 | *1 amp | SUBGROUP DEMODULATOR | 51 |
| A. C. POWER | F1, F2 | *1/2 amp | Receiver | 53 |
| A. C. POWER | F1 | *3/8 amp | Combiner | 55 |
| A. C. POWER | F1, F2 | 1/4 amp | RECEIVER METER PANEL | 68 |
| 115 V. A. C | F1, F2 | *1/4 amp | DIVERSITY ALIGNMENT PANEL | 70 |
| 230 V. A. C. REGULATOR INPUT. | F1, F2 | 5 amp | AC POWER SWITCHING PANEL | 73 |
| 115 V. A. C. UTILITY | F3, F4 | 3 amp | | |

*Slow-blow fuzes.

## 61. Service Upon Receipt of Used or Reconditioned Equipment

*a.* Follow the instructions given in paragraph 46 for uncrating, unpacking, and checking the equipment.

*b.* Check the used or reconditioned equipment for tags or other indications pertaining to changes in the wiring of the equipment. If any changes in wiring have been made, note the changes in this manual, preferably on the schematic and wiring diagrams. Indicate the serial number of the component to which the change applies.

*c.* Perform the installation and connection procedures given in paragraphs 47 through 60.

# CHAPTER 3
# OPERATION

## Section I. CONTROLS AND INSTRUMENTS

*Note.* This section locates, illustrates, and describes the use of the various controls and instruments that are provided for the proper operation of the AN/FGC–29 terminal.

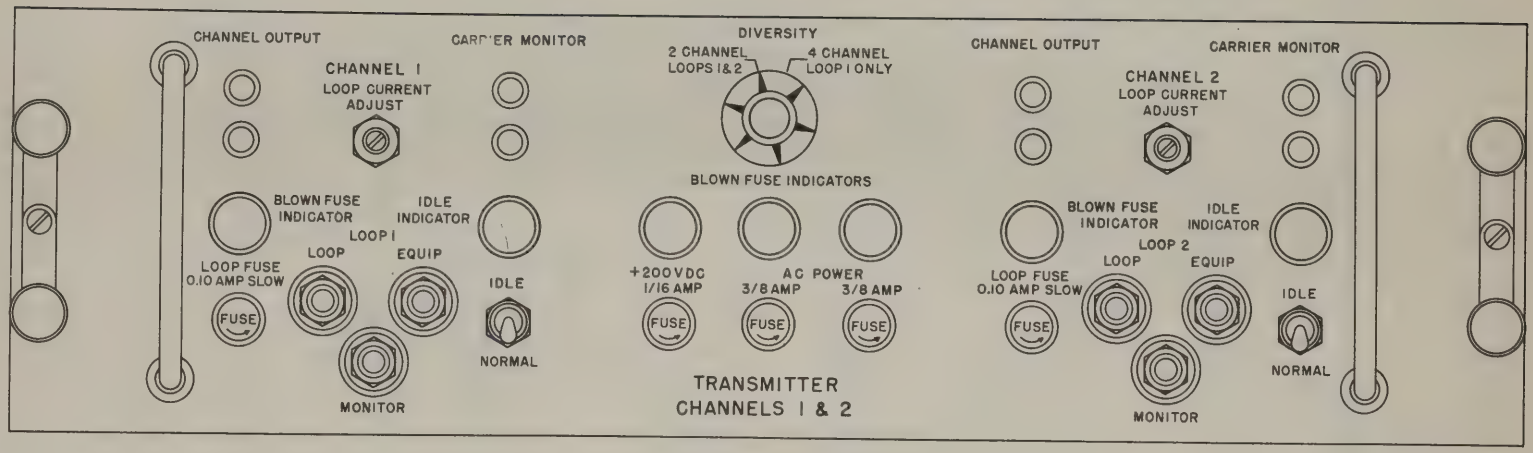
### 62. General

Haphazard operation or improper settings of the controls can cause damage to electronic equipment. For this reason, it is important to know the function of every control. The controls and their uses are covered by paragraphs 62 through 81. The operation of the equipment is discussed in paragraphs 82 through 126.

### 63. Transmitter Controls

*a. Front Panel Controls.* The front panel controls of the transmitter are shown in figure 44. The power fuses and blown fuse indicators are located at the center of the panel. One LOOP FUSE 0.10 AMP SLOW and its associated BLOWN FUSE INDICATOR are located in each channel control grouping. When a fuse blows, the associated indicator glows. The controls are arranged in two groups except for the DIVERSITY switch, which is associated with both channels. The group on the left serves the odd-numbered channel. The group on the right serves the even-numbered channel. Both groups are identical and the controls are listed once.

| Controls | Functions |
|---|---|
| LOOP jack | Provides means for connecting to incoming loop.<br>Permits the loop to be patched to a different circuit. |
| EQUIP jack | Provides means for connecting to input circuit of transmitter.<br>Permits dc test signals to be connected to input circuit of transmitter. |
| EQUIP jack | Permits transmitter input circuit to be patched to a different loop. |
| MONITOR jack | Provides means for making series connection to loop.<br>Permits measurement of loop current. |
| LOOP CURRENT ADJUST control | Rotation adjusts loop current.<br>Clockwise rotation increases current. |
| IDLE-NORMAL switch. | Provides means for transmitting, or not transmitting, carrier telegraph signals from transmitter.<br>NORMAL position permits carrier signals to pass to output circuit of transmitter.<br>IDLE position removes carrier signals from output circuit of transmitter. |
| IDLE INDICATOR lamp. | Glows to indicate channel is idle when NORMAL-IDLE switch is in IDLE position. |
| CHANNEL OUTPUT jacks. | Provide means for connecting to output circuit of transmitter.<br>Permit measurement of output signal level. |
| CARRIER MONITOR jacks. | Permit monitoring of the carrier telegraph signals with a high impedance meter or headset, without interrupting transmission. |
| DIVERSITY switch. | Provides means for selecting diversity combining option.<br>2-CHANNEL position arranges transmitter circuit for 2-channel diversity operation. Odd- and even-numbered channels are keyed separately.<br>4-CHANNEL position arranges transmitter circuit for 4-channel diversity operation. Odd loop keys both channels. |




NOTE:

TYPICAL PANEL MARKINGS ARE SHOWN. PANELS ARE ALSO MARKED FOR CHANNELS 3&4, 5&6, 7&8, 9&10, 11&12, 13&14, AND 15&16.

TM2245-252

*Figure 44. Transmitter, front panel controls.*

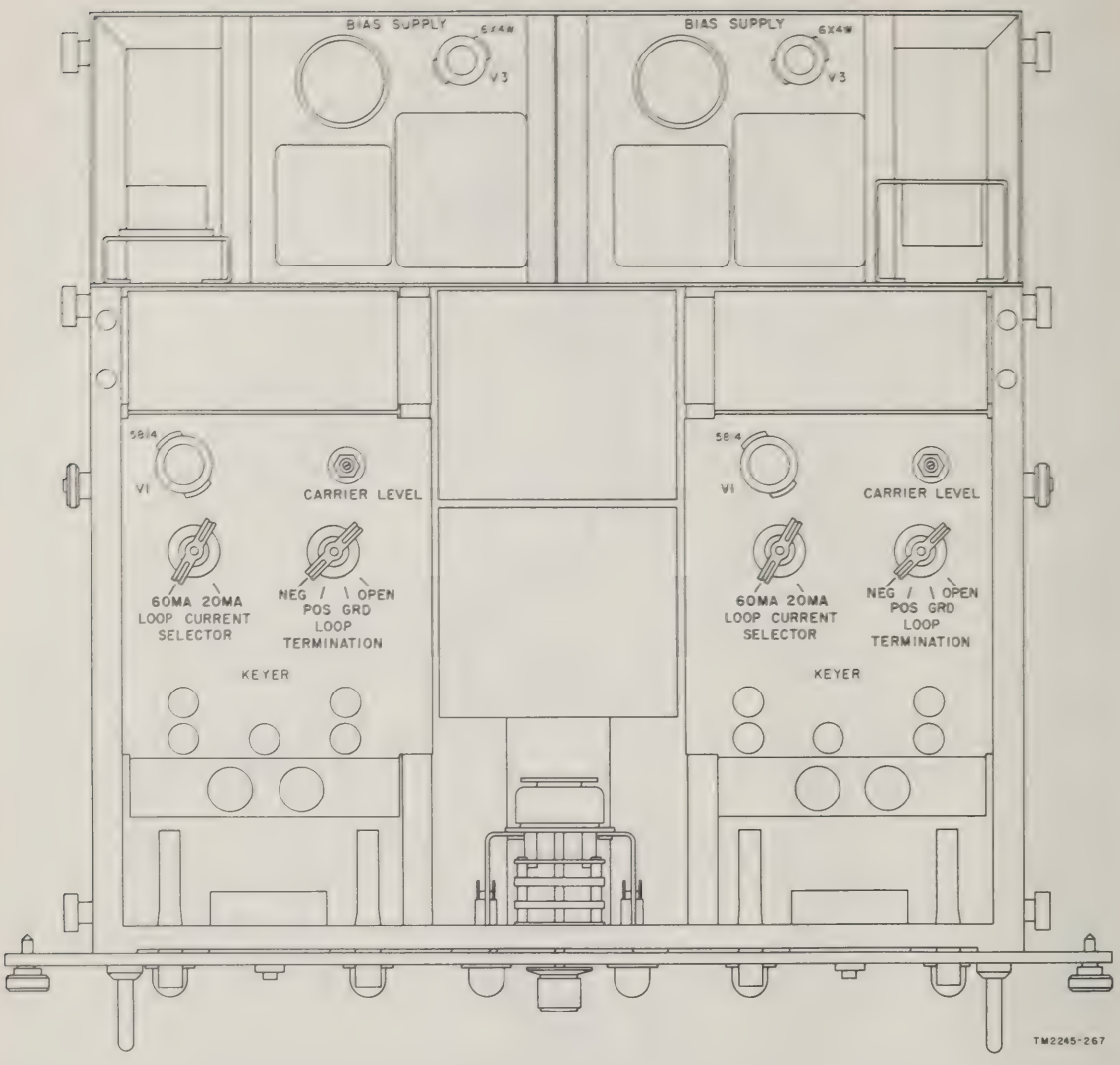



*Figure 45. Transmitter, location of tubes and internal controls, top view.*

*b. Internal Controls.* Controls that are located inside the transmitter chassis are shown in figures 45 and 46. In both figures, the controls on the left serve the odd-numbered channel and the controls on the right serve the even-numbered channel. These controls are listed only once, since both groups are identical.

| Controls | Functions |
|---|---|
| LOOP TERMINATION switch. | Provides means for arranging the dc loop circuits of the transmitter for operation with different external loop terminations.<br>NEG position arranges the transmitter for operation with a loop termination of −130 volts dc.<br>POS position arranges the transmitter for operation with a loop termination of −130 volts dc.<br>GRD position arranges the transmitter for operation with loop terminated in ground.<br>OPEN position opens the loop circuits of the transmitter. |
| LOOP CURRENT SELECTOR switch. | Provides means for arranging the dc loop circuits of the transmitter for operation with two different values of loop current.<br>20 MA position arranges circuit for operation with a loop current of 20 ma.<br>60 MA position arranges circuit for operation with a loop current of 60 ma. |
| CARRIER LEVEL control. | Rotation adjusts the output level of the carrier signals. |
| S–M EQUALIZER control. | Rotation adjusts the level of the spacing frequency for equalizing the marking and spacing frequency levels. |

## 64. SUBGROUP MODULATOR Controls

*a. Front Panel Controls.* The controls that appear on the front panel of the SUBGROUP MODULATOR are shown in figure 47. Fuses and blown fuse indicators are located near the center of the panel. When a fuse blows, the associated indicator glows. The controls and their functions are listed in the chart below.

| Controls | Functions |
|---|---|
| DIRECT PATH INPUT BUS jacks. | Provide means for connecting to odd channel send bus.<br>Permit measurement of bus signal level.<br>Permit bus to be patched to different equipment. |
| DIRECT PATH INPUT EQUIP jacks. | Provide means for connecting to input circuit of direct path.<br>Permit test signals to be introduced into input circuit of direct path.<br>Permit input circuit of direct path to be patched to different channel send bus. |
| DIRECT PATH INPUT MONITOR jacks. | Provide means for making bridging connection to input circuit of direct path.<br>Permit monitoring of input signals with high impedance meter or headset. |
| TRANSLATED PATH INPUT BUS jacks. | Provide means for connecting to incoming even channel send bus.<br>Permit measurement of bus signal level.<br>Permit bus to be patched to different equipment. |
| TRANSLATED PATH INPUT EQUIP jacks. | Provide means for connecting to input circuit of translated path.<br>Permit test signals to be introduced into input circuit of translated path.<br>Permit input circuit of translated path to be patched to different channel send bus. |
| TRANSLATED PATH INPUT MONITOR jacks. | Provide means for making bridging connection to input circuit of translated path.<br>Permit monitoring of input signals with high impedance meter or headset. |
| OUTPUT EQUIP jacks. | Provide means for connecting to output circuit of SUBGROUP MODULATOR.<br>Permit measurement of outgoing signal level.<br>Permit output circuit to be patched to different line circuit. |

| Controls | Functions |
|---|---|
| OUTPUT LINE jacks. | Provide means for connecting to outgoing line circuit.<br>Permit test signals to be introduced into outgoing line.<br>Permit outgoing line to be patched to different equipment. |
| OUTPUT MONITOR jacks. | Provide means for making bridging connection to output circuit of SUBGROUP MODULATOR.<br>Permit monitoring of output signals with high impedance meter or headset. |

*b. Internal Controls.* Controls that are located inside the SUBGROUP MODULATOR chassis are shown in figure 48. The controls and their functions are listed in the chart below.

| Controls | Functions |
|---|---|
| CARRIER LEVEL control. | Rotation adjusts the carrier level in the converter. |
| BALANCE control. | Rotation adjusts carrier leak at output of converter to minimum. |
| GAIN control. | Rotation adjusts output level of carrier supply. |
| BALANCE control. | Rotation adjusts carrier leak at output of modulator to a minimum. |

## 65. LEVEL CONTROL & PLATE SUPPLY

### Controls

All controls in the LEVEL CONTROL & PLATE SUPPLY appear on the front panel and are shown in figure 49. Figure 50 shows the location of tubes. Fuses and associated blown fuse indicators are located in the center and the right of the panel. When a fuse blows the associated indicator glows. The controls and their functions are listed in the chart below.

| Controls | Functions |
|---|---|
| INPUT LINE jacks. | Provide means for connecting to incoming line circuit.<br>Permit measurement of incoming signal level.<br>Permit incoming line to be patched to different equipment. |
| INPUT EQUIP jacks. | Provide means for connecting to signal input circuit of LEVEL CONTROL & PLATE SUPPLY.<br>Permit test signals to be introduced into input circuit of LEVEL CONTROL & PLATE SUPPLY.<br>Permit input circuit to be patched to different line circuit. |

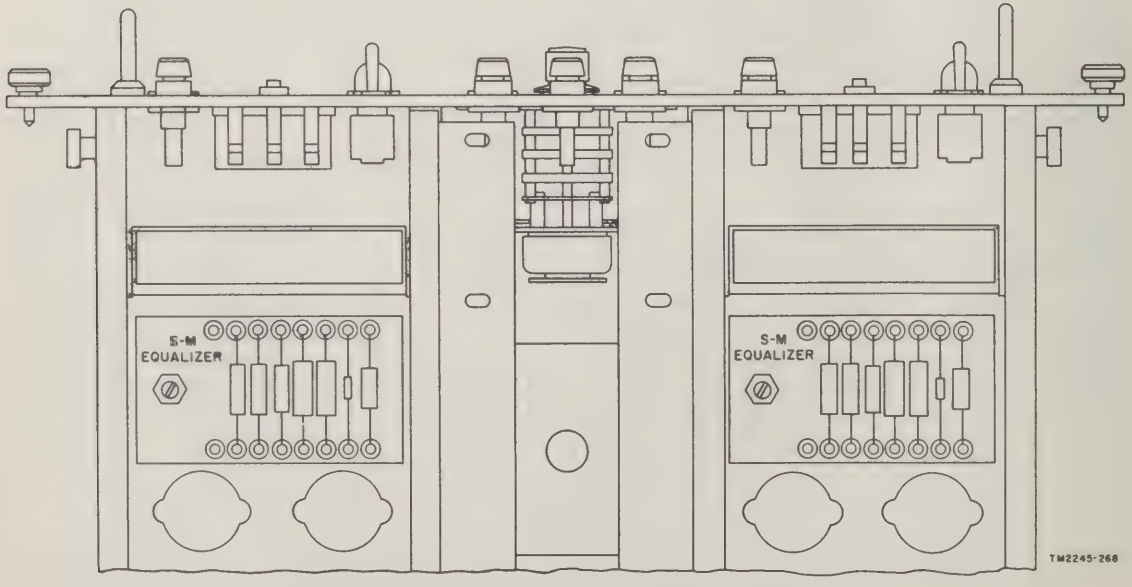



*Figure 46. Transmitter, location of internal controls, bottom view.*

| Controls | Functions |
|---|---|
| INPUT MONITOR jacks. | Provide means for making bridging connection to input circuit of LEVEL CONTROL & PLATE SUPPLY.<br>Permit monitoring of input signals with high impedance meter or headset. |
| LEVEL ADJUST control. | Rotation of knob adjusts signal output level of LEVEL CONTROL & PLATE SUPPLY. Clockwise rotation increases level. |
| OUTPUT EQUIP jacks. | Provide means for connecting to signal output circuit of LEVEL CONTROL & PLATE SUPPLY.<br>Permit measurement of outgoing signal level.<br>Permit output circuit to be patched to different line circuit. |
| OUTPUT LINE jacks. | Provide means for connecting to outgoing line circuit.<br>Permit test signals to be introduced into outgoing line.<br>Permit outgoing line to be patched to different equipment. |
| OUTPUT MONITOR jacks. | Provide means for making bridging connection to output circuit of LEVEL CONTROL & PLATE SUPPLY.<br>Permit monitoring of output signals with high impedance meter or headset. |
| SPARE AMPL INPUT jacks. | Provide means for connecting to input circuit of spare amplifier. |
| SPARE AMPL OUTPUT jacks. | Provide means for connecting to output circuit of spare amplifier. |
| AMPLIFIER IN USE switch. | Provides means for routing signal through amplifier A or amplifier B.<br>A position connects transmission circuit through amplifier A with amplifier B available as a spare and connected to SPARE AMPL jacks.<br>B position connects transmission circuit through amplifier B with amplifier A available as a spare, and connected to SPARE AMPL jacks. |

| Controls | Functions |
|---|---|
| CHANNELS 1–8 & AMPL A ON POWER SUPPLY switch. | Provides means for selecting source of plate and heater voltages for amplifier A and source of plate voltage only for transmitter channels 1 through 8.<br>A position connects amplifier A and transmitter channels 1 through 8 to power supply A. B position connects amplifier A and transmitter channels 1 through 8 to power supply B. |
| CHANNELS 9–16 & AMPL B ON POWER SUPPLY switch. | Provide means for selecting source of plate and heater voltages only for transmitter channels 9 through 16.<br>A position connects amplifier B and transmitter channels 9 through 16 to power supply A.<br>B position connects amplifier B and transmitter channels 9 through 16 to power supply B. |
| PLATE SUPPLY A FAILURE indicator. | Glows when plate supply A fails. |
| PLATE SUPPLY B FAILURE indicator. | Glows when plate supply B fails. |

## 66. SUBGROUP DEMODULATOR Controls

*a. Front Panel Controls.* The controls that appear on the front panel of the SUBGROUP DEMODULATOR are shown in figure 51. Fuses and blown fuse indicators are located near the

*Figure 47. SUBGROUP MODULATOR, front panel controls.*

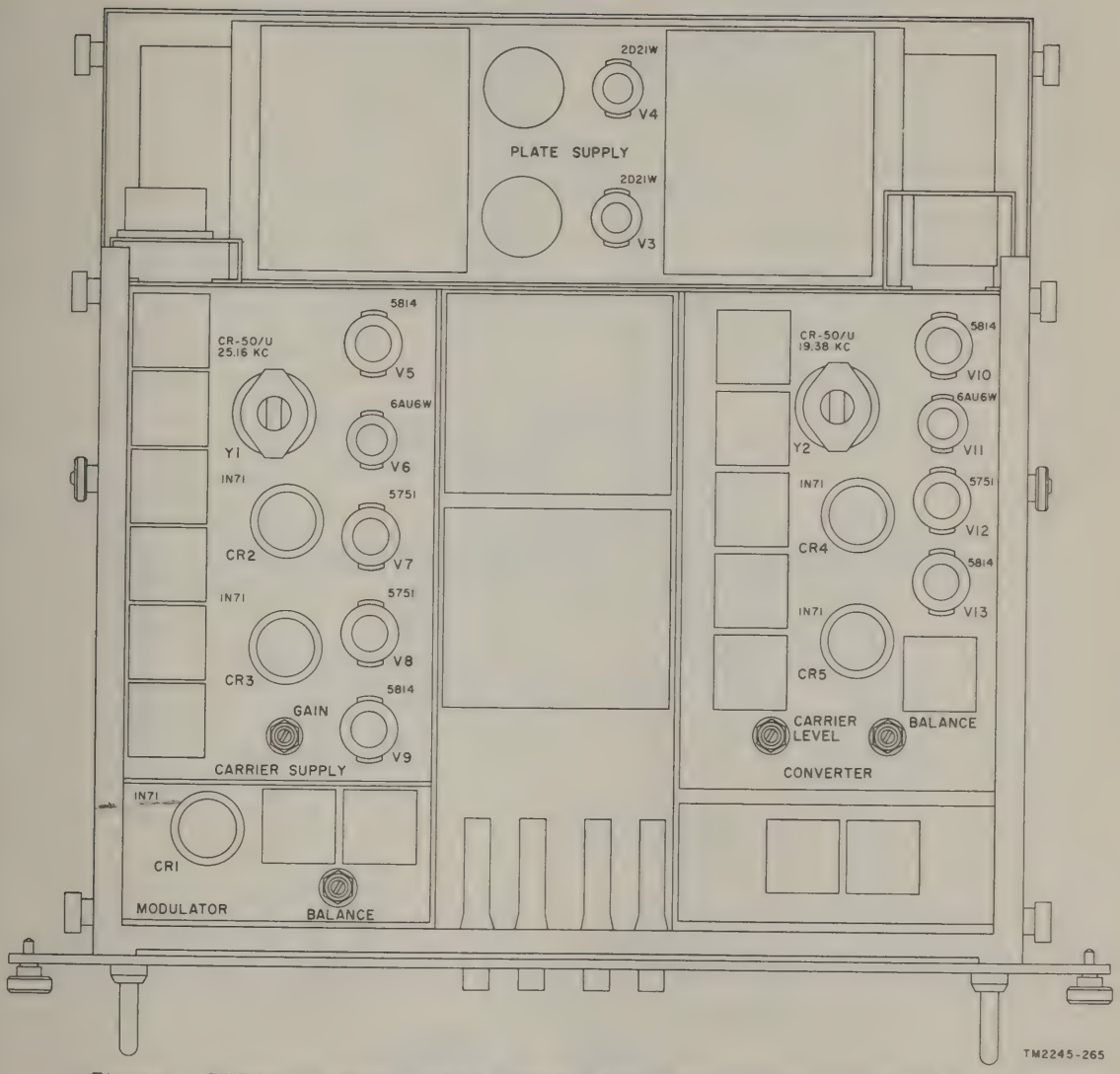



*Figure 48. SUBGROUP MODULATOR, location of tubes, varistors, crystals, and internal controls.*

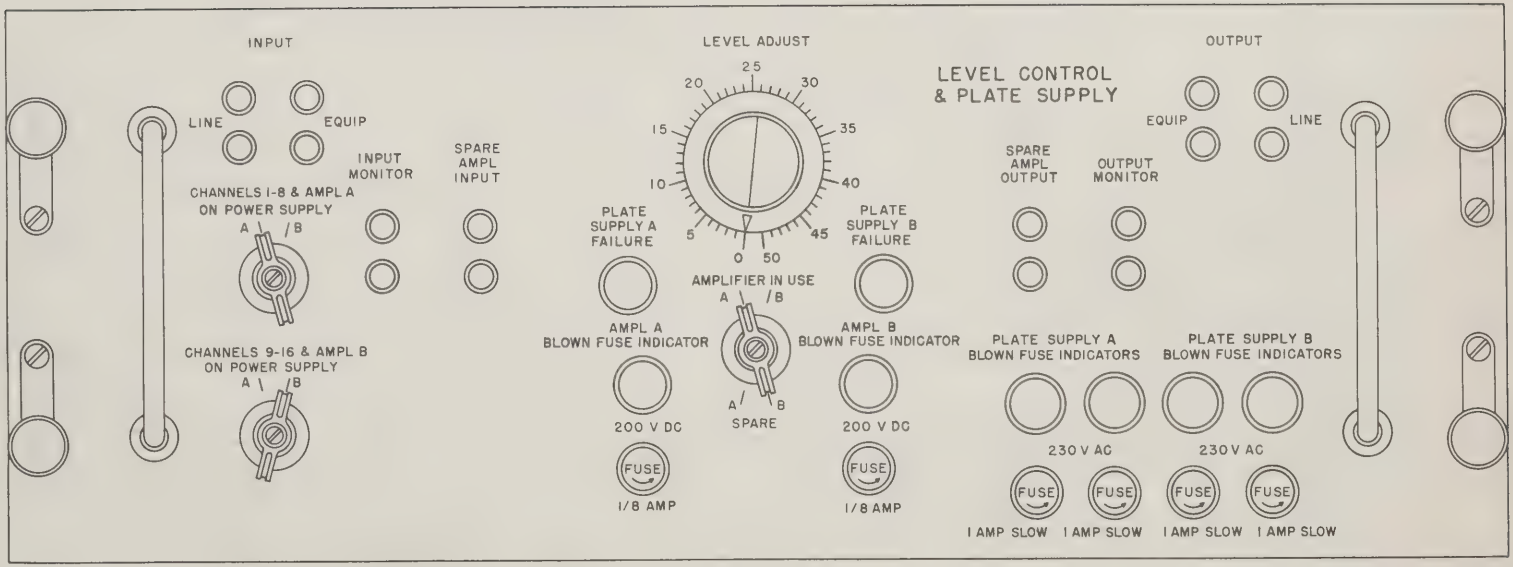



*Figure 49. LEVEL CONTROL & PLATE SUPPLY, front panel controls.*

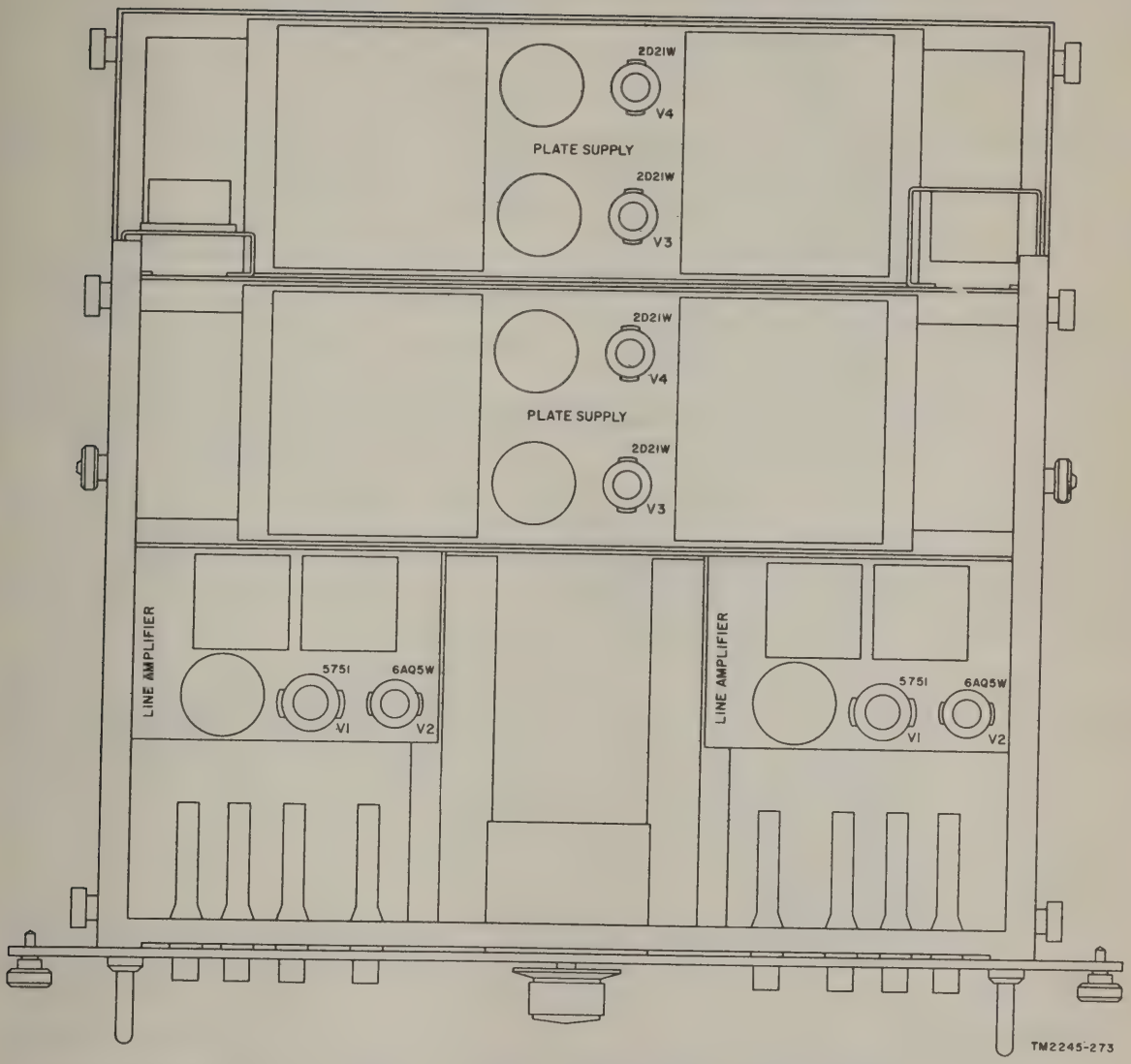



*Figure 50. LEVEL CONTROL & PLATE SUPPLY, location of tubes.*

center of the panel. When a fuse blows its associated indicator glows. The controls and their functions are listed in the chart below.

| Controls | Functions |
|---|---|
| INPUT LINE jacks | Provide means for connecting to incoming line circuit.<br>Permit measurement of incoming signal level.<br>Permit incoming line to be patched to different equipment. |
| INPUT EQUIP jacks. | Provide means for connecting to input circuit of SUBGROUP DEMODULATOR. Permit test signals to be introduced into input circuit of SUBGROUP DEMODULATOR.<br>Permit input circuit to be patched to different line circuit. |
| INPUT MONITOR jacks. | Provide means for making bridging connection to input circuit of SUBGROUP DEMODULATOR.<br>Permit monitoring of input signals with high impedance meter or headset. |

*b. Internal Controls.* The controls that are located inside the SUBGROUP DEMODULATOR chassis are shown in figure 52. The controls and their functions are listed in the chart below.

| Controls | Functions |
|---|---|
| GAIN control | Rotation adjusts output level of carrier supply. |
| BALANCE control | Rotation adjusts carrier leak at output of modulator to a minimum. |
| CARRIER LEVEL control. | Rotation adjusts the carrier level in the converter. |
| BALANCE control | Rotation adjusts carrier leak at output of converter to a minimum. |

## 67. Receiver Controls

*a. Front Panel Controls.* The controls that appear on the front panel of the receiver are shown in figure 53. Fuses and blown fuse indicators are located near the center of the panel. When a fuse blows the associated indicator glows. Varistors CR1 and CR2 for RECEIVER A are located on the left and varistor CR3 and CR4 for RECEIVER B are located on the right of the panel. The controls and their functions are listed in the table below. The LINE, EQUIP, and MONITOR jacks are arranged in two groups. The group on the left serves RECEIVER A and the group on the right serves RECEIVER B. These jacks are listed only once since both groups are identical.

| Controls | Functions |
|---|---|
| LINE jacks | Permit measurement of incoming signal level at output of receiver filter. |
| EQUIP jacks | Provide means for connecting to input circuit of receiver.<br>Permit test signals to be connected to input circuit of receiver. |
| MONITOR jacks | Permit measurement of signal level at input of agc amplifier. |
| METER jacks | Permit measurement of output signal level of gain control section of agc amplifier AR3 or AR4. |
| METER SWITCH | Provides means for selecting desired receiver path to be connected to METER jacks.<br>In A position connects agc amplifier of Receiver A to METER jacks.<br>In B position connects agc amplifier of RECEIVER B to METER jacks. |

*b. Internal Controls.* Controls that are located inside the receiver chassis are shown in figure 54. The controls on the left serve RECEIVER A and those on the right serve RECEIVER B. Each control is listed only once, since both groups are identical.

| Controls | Functions |
|---|---|
| LEVEL ADJ control | Rotation adjusts the input level to the delay amplifier. |
| DELAY ADJ control. | Rotation of knob adjusts the delay of signals through the delay amplifier.<br>Clockwise rotation increases delay. |
| OUTPUT-GRD test jacks. | Permit measurement of output level of delay amplifier. |
| MON LEVEL ADJ control. | Rotation adjusts proportion of AGC amplifier input signal applied to MONITOR jacks. |

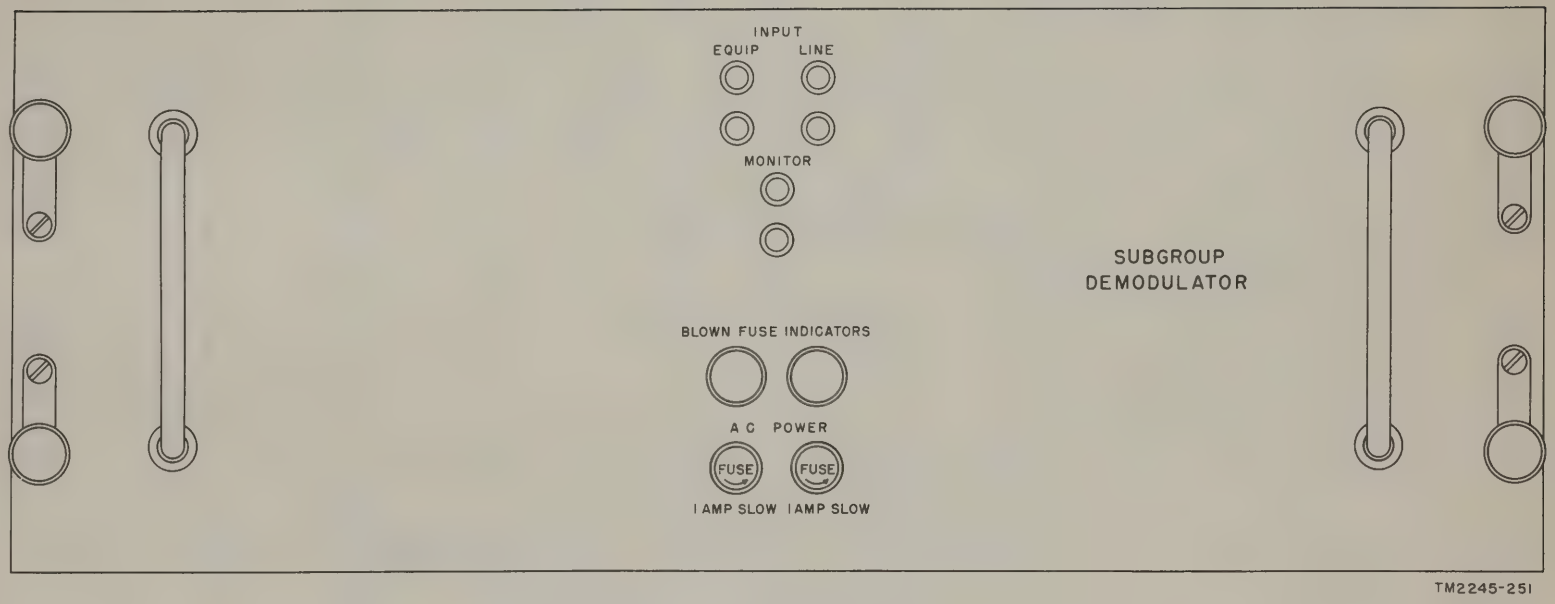



*Figure 51. SUBGROUP DEMODULATOR, front panel controls.*

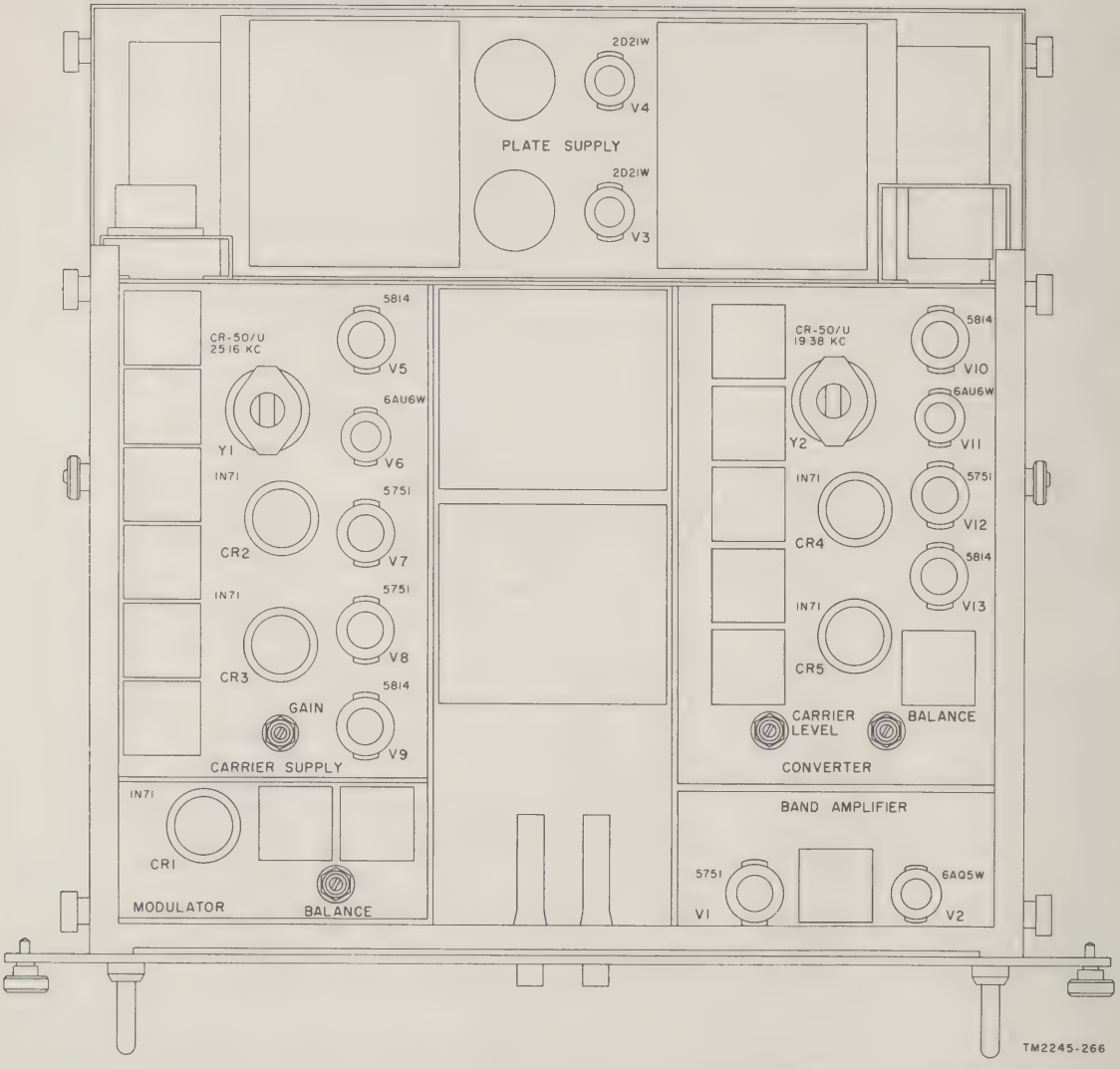
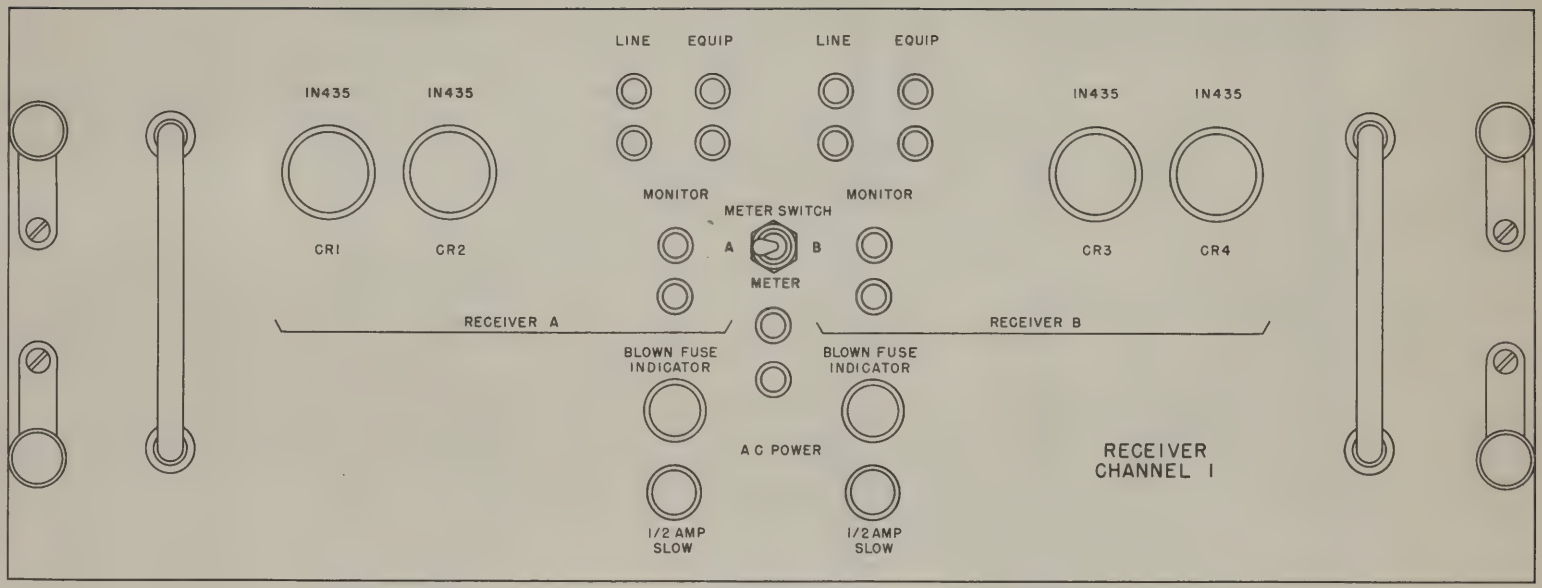



*Figure 52. SUBGROUP DEMODULATOR, location of tubes, varistors, crystals, and internal controls.*




NOTE:

TYPICAL PANEL MARKINGS ARE SHOWN, PANELS ARE ALSO MARKED FOR CHANNELS 2 THROUGH 16.

TM2245-253

*Figure 53. Receiver, front panel controls.*

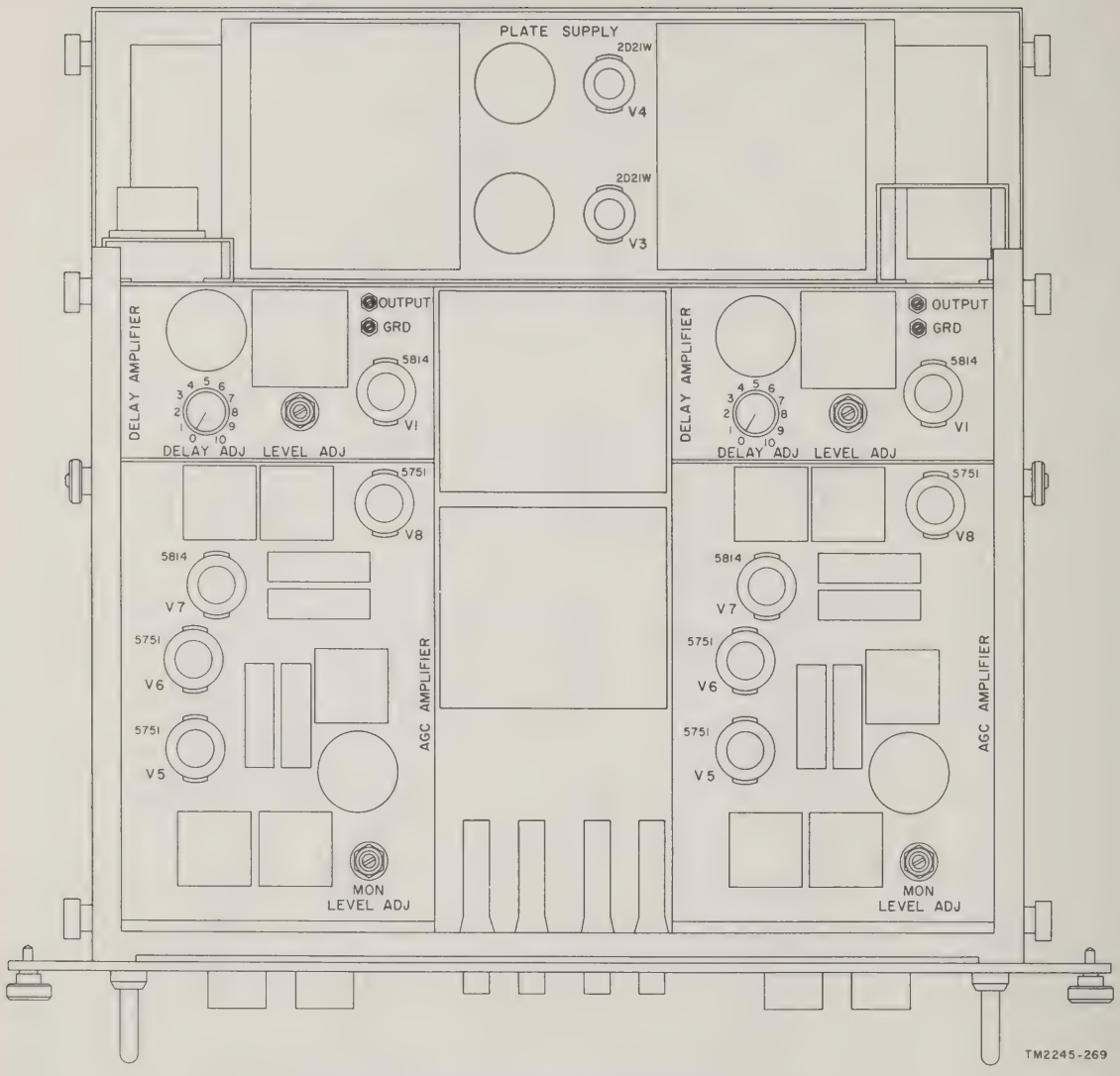



*Figure 54. Receiver, location of tubes and internal controls.*

## 68. Combiner Controls

*a. Front Panel Controls.* The controls that appear on the front panel of the combiner are shown in figure 55. The AC POWER ¾ AMP SLOW fuse and BLOWN FUSE INDICATOR are located at the center of the panel. When the fuse blows, the indicator glows. With the exception of the DIVERSITY switch, which is associated with both channels, the controls are arranged in two groups. The group on the left serves the odd-numbered channel and the group on the right serves the even-numbered channel. These controls are listed only once, since both groups are identical.

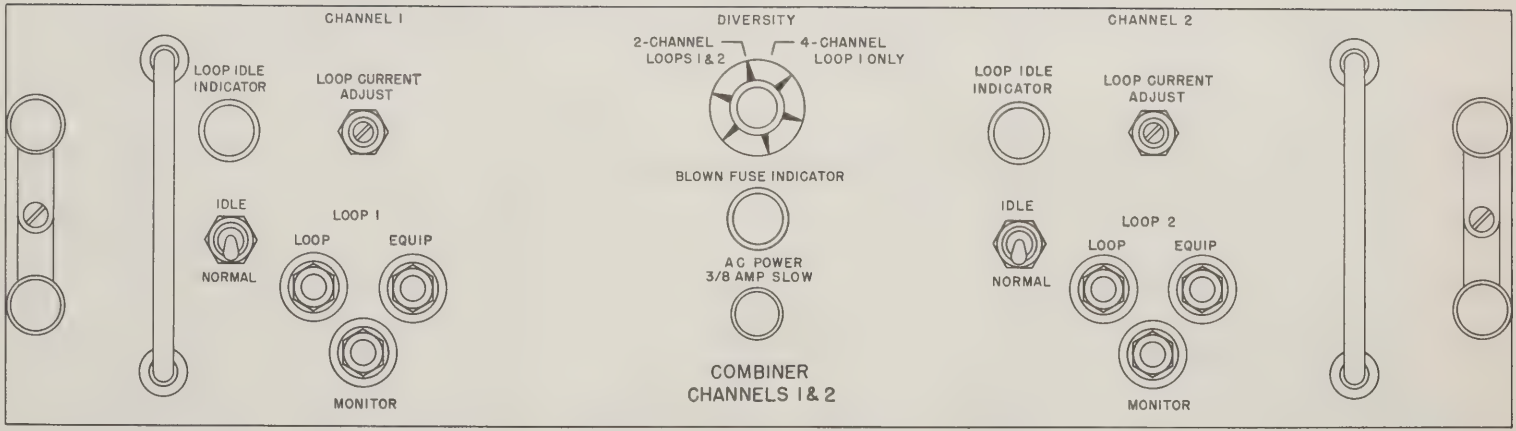
| Controls | Functions |
|---|---|
| IDLE-NORMAL switch. | Provides means for transmitting received signals to the receiving loop or holding the loop in closed (marking) condition.<br>NORMAL position permits received signals to pass to the receiving loop.<br>IDLE position transmits a continuous marking signal to the loop. |
| LOOP IDLE INDICATOR. | Indicates combiner not arranged to key loop. Glows when IDLE-NORMAL switch is in IDLE position.<br>Even-numbered channel indicator glows when DIVERSITY switch is in 4-CHANNEL position. |
| LOOP CURRENT ADJUST control. | Rotation adjusts loop current.<br>Clockwise rotation increases current. |
| EQUIP jack | Provides means for connecting to output circuit of combiner.<br>Permits combiner output circuit to be patched to a different loop. |
| LOOP jack | Provides means for connecting to outgoing loop.<br>Permits loop to be patched to different combiner output circuit. |
| MONITOR jack | Provides means for making series connection to loop.<br>Permits measurement of loop current. |
| DIVERSITY switch | Provides means for selecting diversity combining option.<br>2-CHANNEL position arranges combiner circuits for 2-channel diversity combining so that odd-and even-numbered loops are keyed individually.<br>4-CHANNEL position arranges combiner circuits for 4-channel diversity combining so that odd-numbered loop is keyed and even-numbered loop is idle. |

*b. Internal Controls.* Controls that are located inside the combiner chassis are shown in figure 56. The controls on the left serve the odd-numbered channel and those on the right serve the even-numbered channel. These controls are listed only once since both groups are identical.

| Controls | Functions |
|---|---|
| LEVEL ADJUST A control. | Rotation adjusts input level to combiner A path. |
| LEVEL ADJUST B control. | Rotation adjusts input level to combiner B path. |
| BIAS ADJUST A control. | Permits adjustment of A path discriminator to deliver unbiased telegraph signals. |
| BIAS ADJUST B control. | Permits adjustment of B path discriminator to deliver unbiased telegraph signals. |
| DISCRIMINATOR switch. | Provides means for reversing polarity of discriminator output voltage.<br>NORMAL position arranges circuit to close loop for a marking frequency signal.<br>REVERSE position arranges circuit to open loop for a marking frequency signal. |
| DISCRIMINATOR OUTPUT test jacks. | Permit measurement of discriminator output voltage with high resistance dc voltmeter. |
| LOOP CURRENT switch. | Provides means for arranging the output circuits of combiner for operation with two different values of loop current.<br>20 MA position arranges circuits for operation with loop current of 20 ma.<br>60 MA position arranges circuits for operation with loop current of 60 ma. |

## 69. 3KC SEND BAND TEST PANEL Controls

The controls of the 3KC SEND BAND TEST PANEL consist of 20 jack pairs arranged on the




NOTE:

TYPICAL PANEL MARKINGS ARE SHOWN. PANELS ARE ALSO MARKED FOR CHANNELS 3 & 4, 5 & 6, 7 & 8, 9 & 10, 11 & 12, 13 & 14, AND 15 & 16.

TM2245-254

*Figure 55. Combiner, front panel controls.*

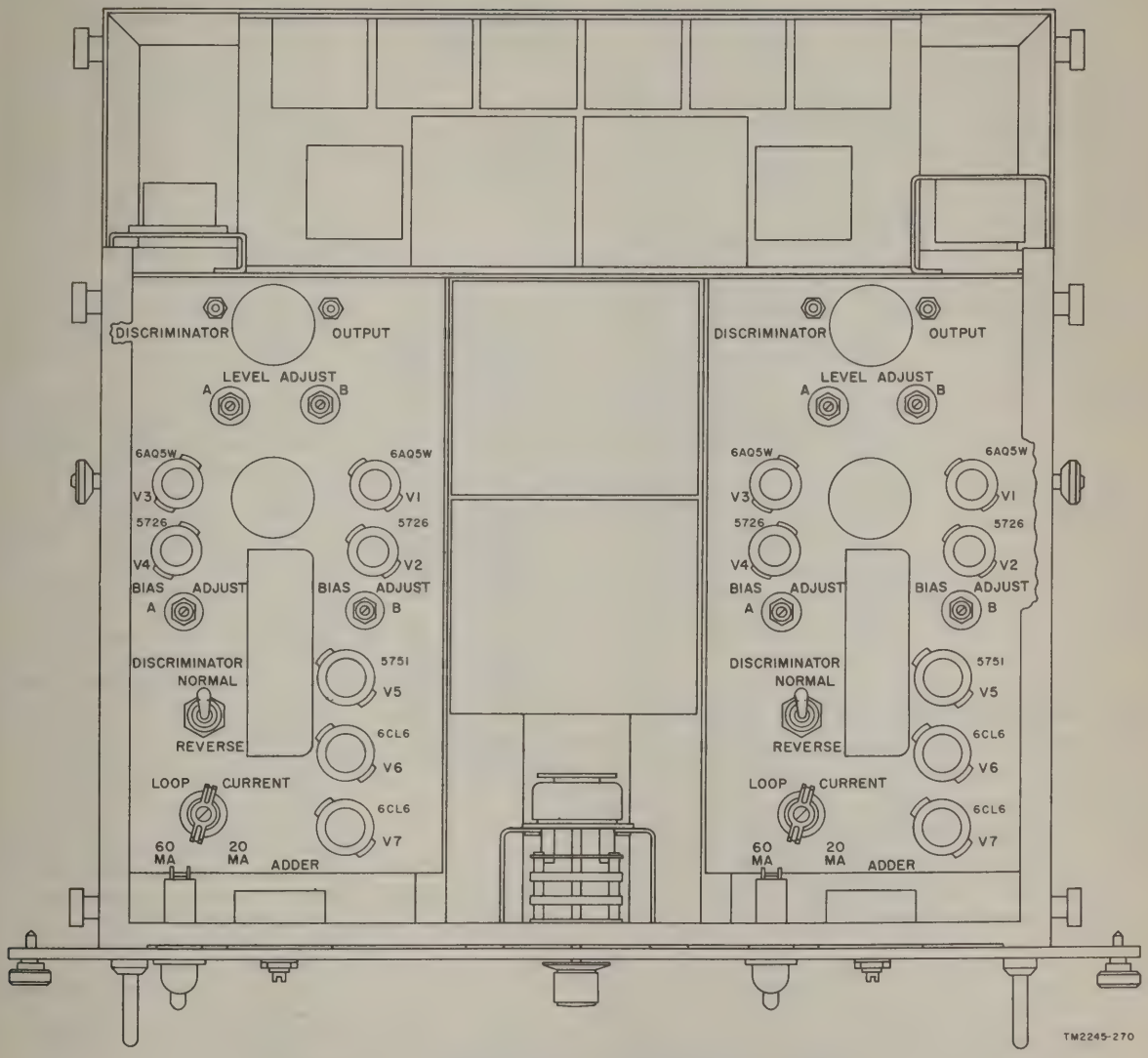



*Figure 56. Combiner, location of tubes and internal controls.*

front panel in three groups as shown in figure 57. The jack pairs in the center group are permanently connected into the 3-kc band signal paths of the transmitting terminal. The jack pairs at each end of the panel are available for use as general purpose trunks. The jacks and their functions are described in the chart below.

| Controls | Functions |
|---|---|
| JACK GROUP 1 through JACK GROUP 4, EQUIP. OUT jacks. | Permit measurement of outgoing signal levels from vf circuit.<br>Permit vf circuits to be connected to different transmission circuits. |
| JACK GROUP 1 through JACK GROUP 4, LINE IN jacks. | Provide means for connecting to outgoing transmission circuits.<br>Permit test signals to be connected to outgoing transmission circuits. |
| JACK GROUP 1 through JACK GROUP 4, MONITOR jacks. | Provide means for making bridging connections to 3-kc band circuits in transmitting terminal.<br>Permit monitoring of 3-kc band circuits in transmitting terminal with high impedance meter or headset without interrupting traffic. |
| TRUNKS 1 through 8 jacks. | Connect to signal distribution terminal boards TB103 and TB104 in top rear of cabinet 1.<br>Permit connection to test circuits or other trunks for operational and maintenance purposes. |

## 70. Multiplexer TD–97/FGT–2 Controls

*a. Front Panel Controls.* The controls that appear on the front panel of Multiplexer TD–97/FGT–2 are shown in figure 58. Fuses and blown fuse indicators are located at the right of the panel. When a fuse blows, the associated indicator glows. The controls and their functions are listed in the chart below.

| Controls | Functions |
|---|---|
| DIRECT PATH INPUT LINE jacks. | Provide means for connecting to incoming line circuit associated with direct path of multiplexer.<br>Permit measurement of incoming signal level.<br>Permit incoming line to be patched to different equipment. |
| DIRECT PATH INPUT EQUIP jacks. | Provide means for connecting to direct path input circuit of multiplexer.<br>Permit test signals to be connected to direct path input circuit.<br>Permit direct path input circuit to be patched to different line circuit. |
| DIRECT PATH INPUT MONITOR jacks. | Provide means for making bridging connection to direct path input circuit.<br>Permit monitoring of direct path input circuit with high impedance meter or headset. |
| TRANSLATED PATH INPUT LINE jacks. | Provide means for connecting to incoming line circuit associated with translated path of multiplexer.<br>Permit measurement of incoming signal level.<br>Permit incoming line to be patched to different equipment. |
| TRANSLATED PATH INPUT EQUIP jacks. | Provide means for connecting to translated path input circuit of multiplexer.<br>Permit test signals to be connected to translated path input circuit.<br>Permit translated path input circuit to be patched to different line circuit. |
| TRANSLATED PATH INPUT MONITOR jacks. | Provide means for making bridging connection to translated path input circuit.<br>Permit monitoring of translated path input circuit with high impedance meter or headset. |
| Terminal board TB9. | Permits various circuit routings to be set up between incoming line circuits and transmission paths of multiplexer. |
| OUTPUT EQUIP jacks. | Provide means for connecting to output circuit of multiplexer.<br>Permit measurement of outgoing signal level.<br>Permit multiplexer output to be patched to different line circuit. |
| OUTPUT LINE jacks. | Provide means for connecting to outgoing line circuit.<br>Permit test signals to be connected to outgoing line.<br>Permit line to be patched to different equipment. |
| OUTPUT MONITOR jacks. | Provide means for making bridging connection to output circuit of multiplexer.<br>Permit monitoring of output circuit with high impedance meter or headset. |
| OUTPUT LEVEL ADJUST control | Rotation of knob adjusts output level of multiplexer.<br>Clockwise rotation increases level. |

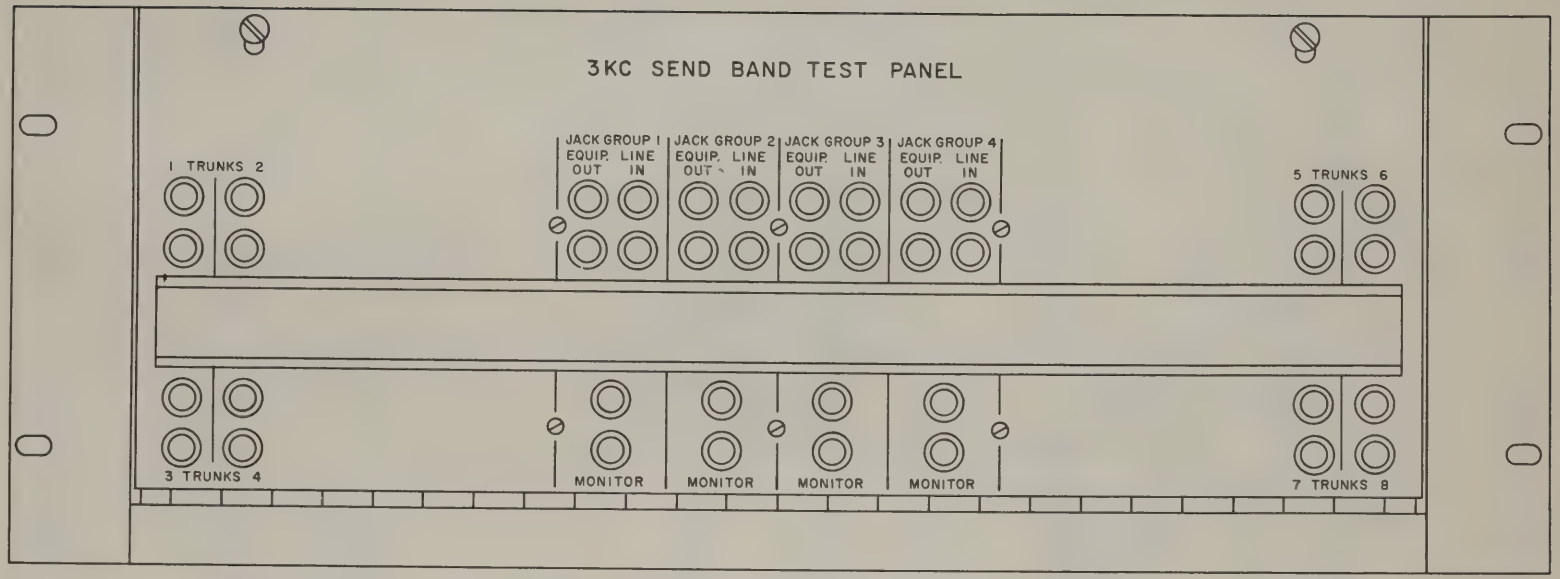



*Figure 57. 3KC SEND BAND TEST PANEL, front panel controls.*

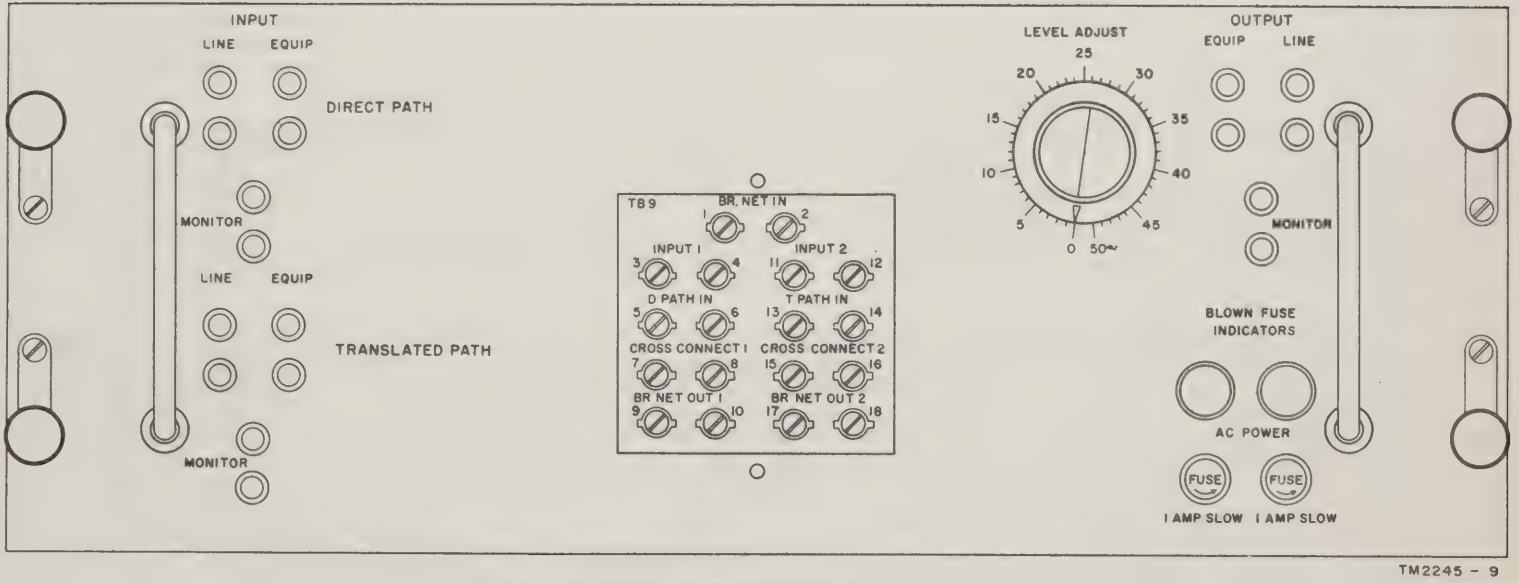



*Figure 58. Multiplexer TD-97/FGT-2, front panel controls.*

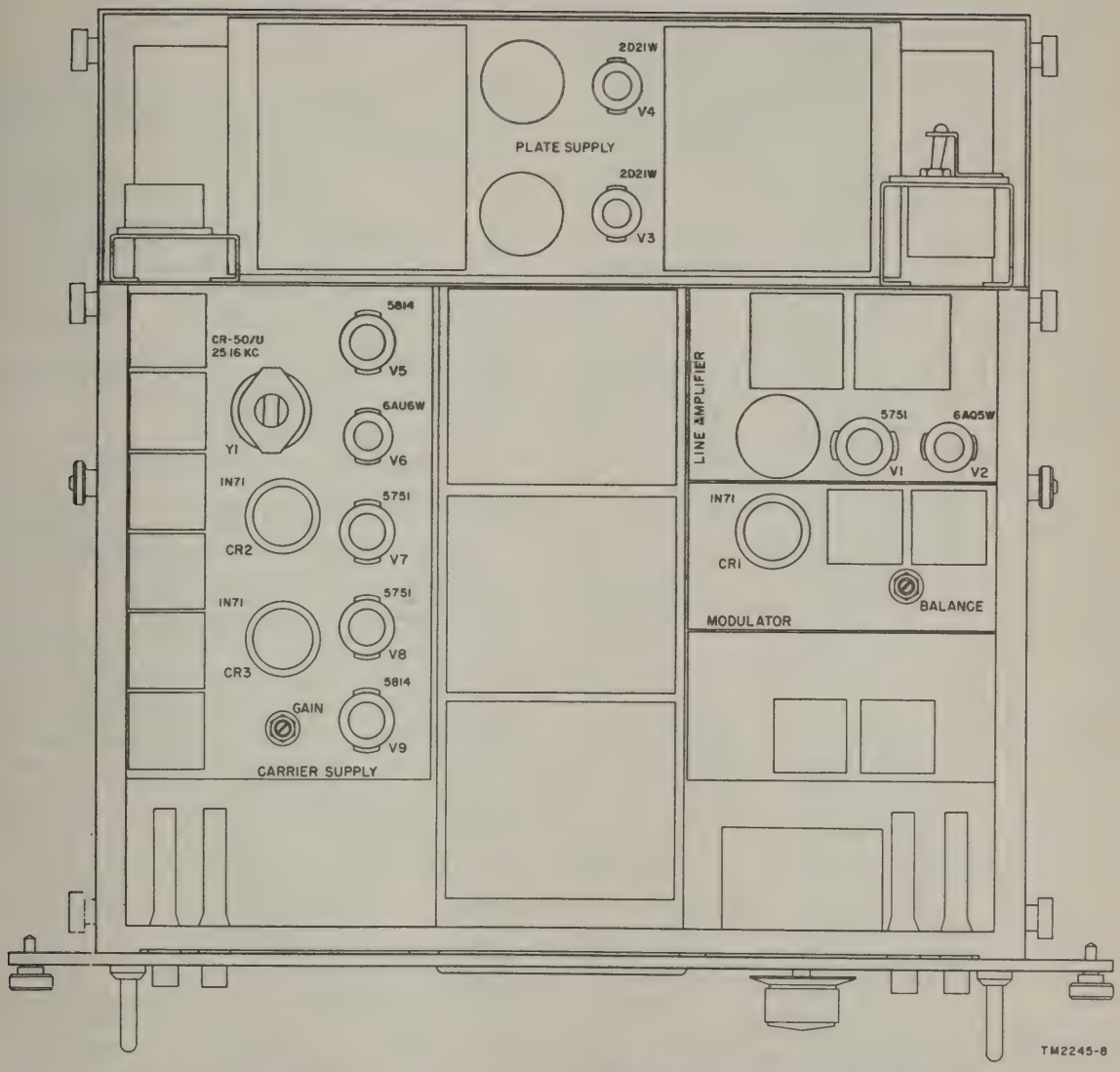



*Figure 59. Multiplexer TD-97/FGT-2, location of tubes, varistors, crystal, and internal controls.*

*b. Internal Controls.* Controls that are located inside the multiplexer chassis are shown in figures 59 and 60. The controls and their function are listed in the chart below.

| Controls | Functions |
|---|---|
| AC POWER 115–230V switch. | Permits operation in 115 volts or 230 volts ac power by setting switch in appropriate position. |
| BALANCE control | Rotation adjusts carrier leak at output of modulator to a minimum. |
| GAIN control | Rotation adjusts output level of carrier supply. |

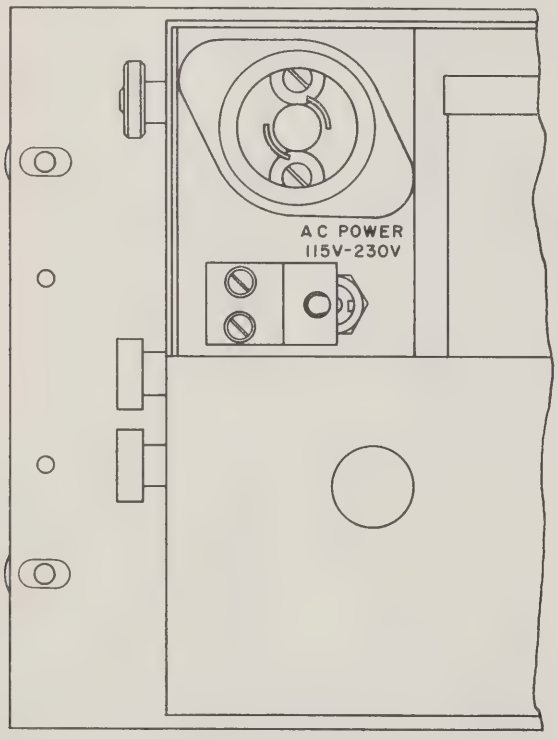



*Figure 60. Multiplexer TD–97/FGT–2, Demultiplexer TD–98/FGR–3, and Audio Frequency Amplifier AM–911/FG, AC POWER 115V–230V switch.*

## 71. Audio Frequency Amplifier AM–911/FG Controls

*a. Front Panel Controls.* The controls that appear on the front panel of Audio Frequency Amplifier AM–911/FG are shown in figure 61. The fuses and blown fuse indicators are located in the center of the panel. When a fuse blows, the associated indicator glows. The other controls are arranged in two groups. The group on the left serves AMPLIFIER A and the group on the right serves AMPLIFIER B. These controls are listed only once since both groups are identical.

| Controls | Functions |
|---|---|
| INPUT LINE jacks | Provide means for connecting to incoming line circuit.<br>Permit measurement of incoming signal level.<br>Permit incoming line circuit to be patched to different equipment. |
| INPUT EQUIP jacks. | Provide means for connecting to input circuit of amplifier.<br>Permit test signals to be connected to input circuit.<br>Permit amplifier input to be patched to different line circuit. |
| INPUT MONITOR jacks. | Provide means for making bridging connection to input circuit of amplifier.<br>Permit monitoring of input circuit with high impedance meter or headset. |
| Equalizer switch | Provide means for selecting desired equalizer. NONLOADED CABLE position connects transmission circuit through equalizer for nonloaded cable.<br>LOADED CABLE position connects transmission circuit through equalizer for loaded cable.<br>EQUAL OUT position cuts equalizers out of transmission circuit. |
| LOADED LOW control. | Provides means for adjusting low frequency attenuation of loaded cable equalizer. |
| LOADED HIGH control. | Provides means for adjusting high frequency attenuation of loaded cable equalizer. |
| NONLOADED control. | Provides means for adjusting attenuation of nonloaded cable equalizer. |
| LEVEL ADJUST control. | Rotation of knob adjusts output level of amplifier.<br>Clockwise rotation increases level. |
| OUTPUT EQUIP jacks. | Provide means for connecting to output circuit of amplifier.<br>Permit measurement of outgoing signal level.<br>Permit amplifier to be patched to different outgoing line. |
| OUTPUT LINE jacks. | Provide means for connecting to outgoing line circuit.<br>Permit test signals to be connected to outgoing line.<br>Permit outgoing line to be patched to different equipment. |

| Controls | Functions |
|---|---|
| OUTPUT MONITOR jacks. | Provide means for making bridging connection to output circuit of amplifier.<br>Permit monitoring of output signals with high impedance meter or headset. |

*b. Internal Controls.* Controls that are located inside the amplifier chassis are shown in figure 60 and 62. The controls and their functions are listed in the table below.

| Controls | Functions |
|---|---|
| A C POWER 115V–230V switch. | Permits operation on 115 volts or 230 volts ac power by setting switch in appropriate position. |
| Terminal board TB3. | Provides means of selecting input impedance of amplifier.<br>Permits impedance matching to 150-ohm, 600-ohm, or 1,350-ohm incoming line circuits. |

## 72. Demultiplexer TD–98/FGR–3 Controls

*a. Front Panel Controls.* The controls that appear on the front panel of Demultiplexer TD–98/FGR–3 are shown in figure 63. Fuses and blown fuse indicators are located at the right of the panel. When a fuse blows the associated indicator glows. The controls and their functions are listed in the chart below.

| Controls | Functions |
|---|---|
| INPUT LINE jacks. | Provide means for connecting to incoming line circuit.<br>Permit measurement of incoming signal level.<br>Permit incoming line circuit to be patched to different equipment. |
| INPUT EQUIP jacks. | Provide means for connecting to input circuit of demultiplexer.<br>Permit test signals to be connected to input circuit.<br>Permit demultiplexer input to be patched to different line circuit. |
| INPUT MONITOR jacks. | Provide means for making bridging connection to input circuit of demultiplexer. |
| IMPUT MONITOR jacks. | Permit monitoring of input circuit with high impedance meter or headset. |
| INPUT LEVEL ADJUST control. | Rotation of knob adjusts input level to demultiplexer.<br>Clockwise rotation increases level. |
| DIRECT PATH OUTPUT LEVEL ADJUST control. | Rotation of knob adjusts output level of direct path.<br>Clockwise rotation increases level. |
| TRANSLATED PATH OUTPUT LEVEL ADJUST control. | Rotation of knob adjusts output level of translated path.<br>Clockwise rotation increases level. |
| DIRECT PATH OUTPUT EQUIP jacks. | Provide means for connecting to direct path output circuit of demultiplexer.<br>Permit measurement of outgoing signal level.<br>Permit direct path output to be patched to different line circuit. |
| DIRECT PATH OUTPUT LINE jacks. | Provide means for connecting to outgoing line circuit associated with direct path of demultiplexer.<br>Permit test signals to be connected to outgoing line.<br>Permit outgoing line to be patched to different equipment. |
| DIRECT PATH OUTPUT MONITOR jacks. | Provide means for making bridging connection to output circuit of direct path.<br>Permit monitoring of direct path output circuit with high impedance meter or headset. |
| TRANSLATED PATH OUTPUT EQUIP jacks. | Provide means for connecting to translated path output circuit of demultiplexer.<br>Permit measurement of outgoing signal level.<br>Permit translated path output to be patched to different line circuit. |
| TRANSLATED PATH OUTPUT LINE jacks. | Provide means for connecting to outgoing line circuit associated with translated path of demultiplexer.<br>Permit test signals to be connected to outgoing line.<br>Permit outgoing line to be patched to different equipment. |
| TRANSLATED PATH OUTPUT MONITOR jacks. | Provide means for making bridging connection to output circuit of translated path.<br>Permit monitoring of translated path output circuit with high impedance meter or headset. |

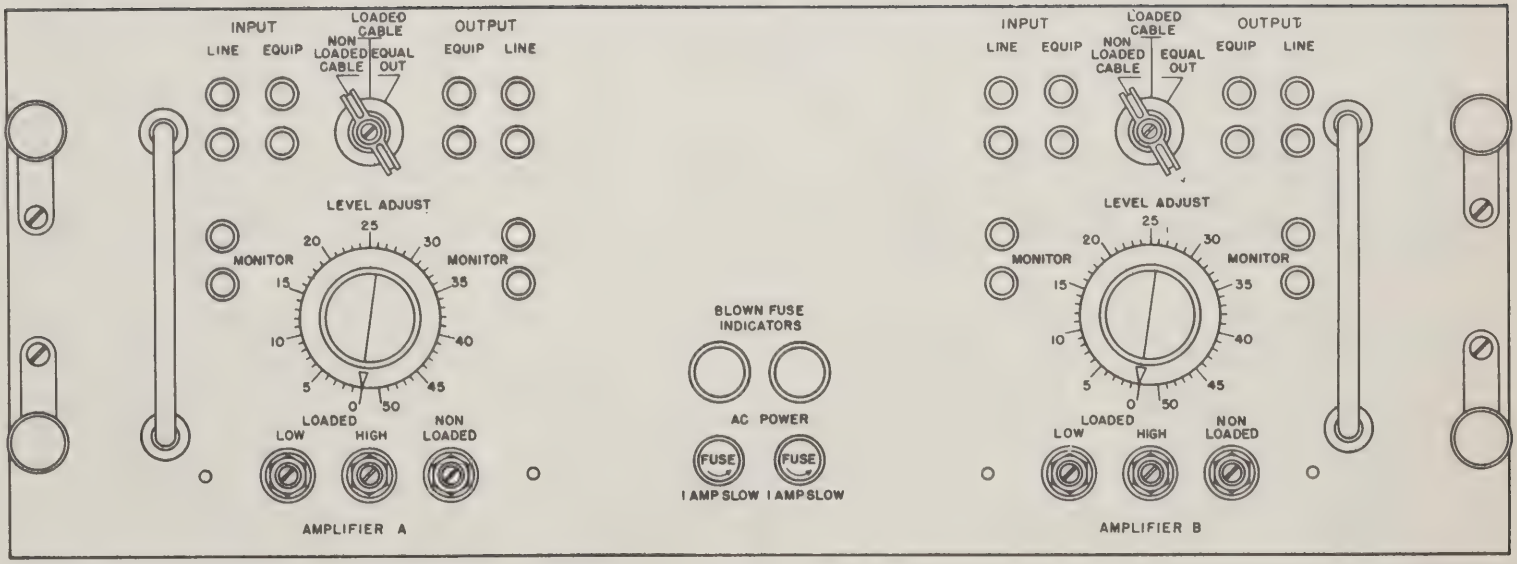



*Figure 61. Audio Frequency Amplifier AM-911/FG, front panel controls.*

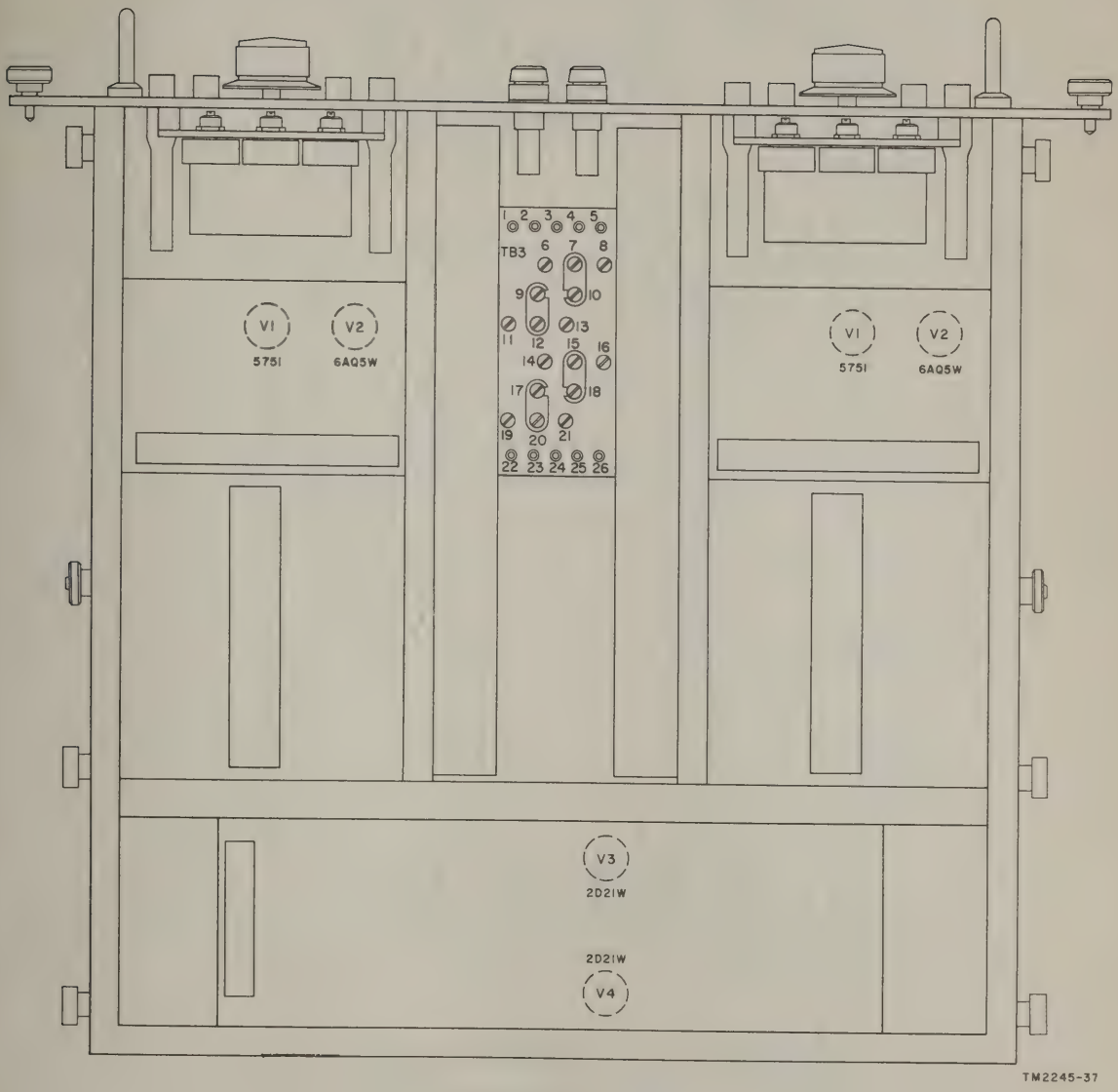



*Figure 62. Audio Frequency Amplifier AM-911/FG, location of tubes and internal controls.*

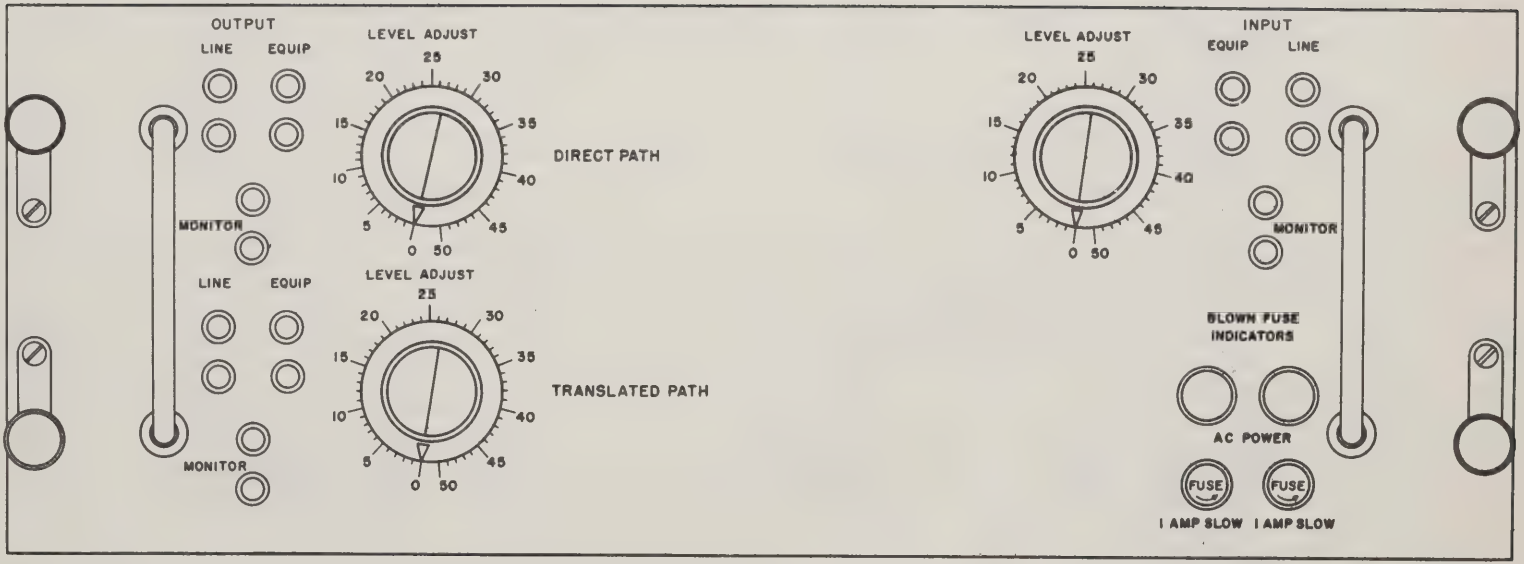



*Figure 63. Demultiplexer TD-98/FGR-3, front panel controls.*

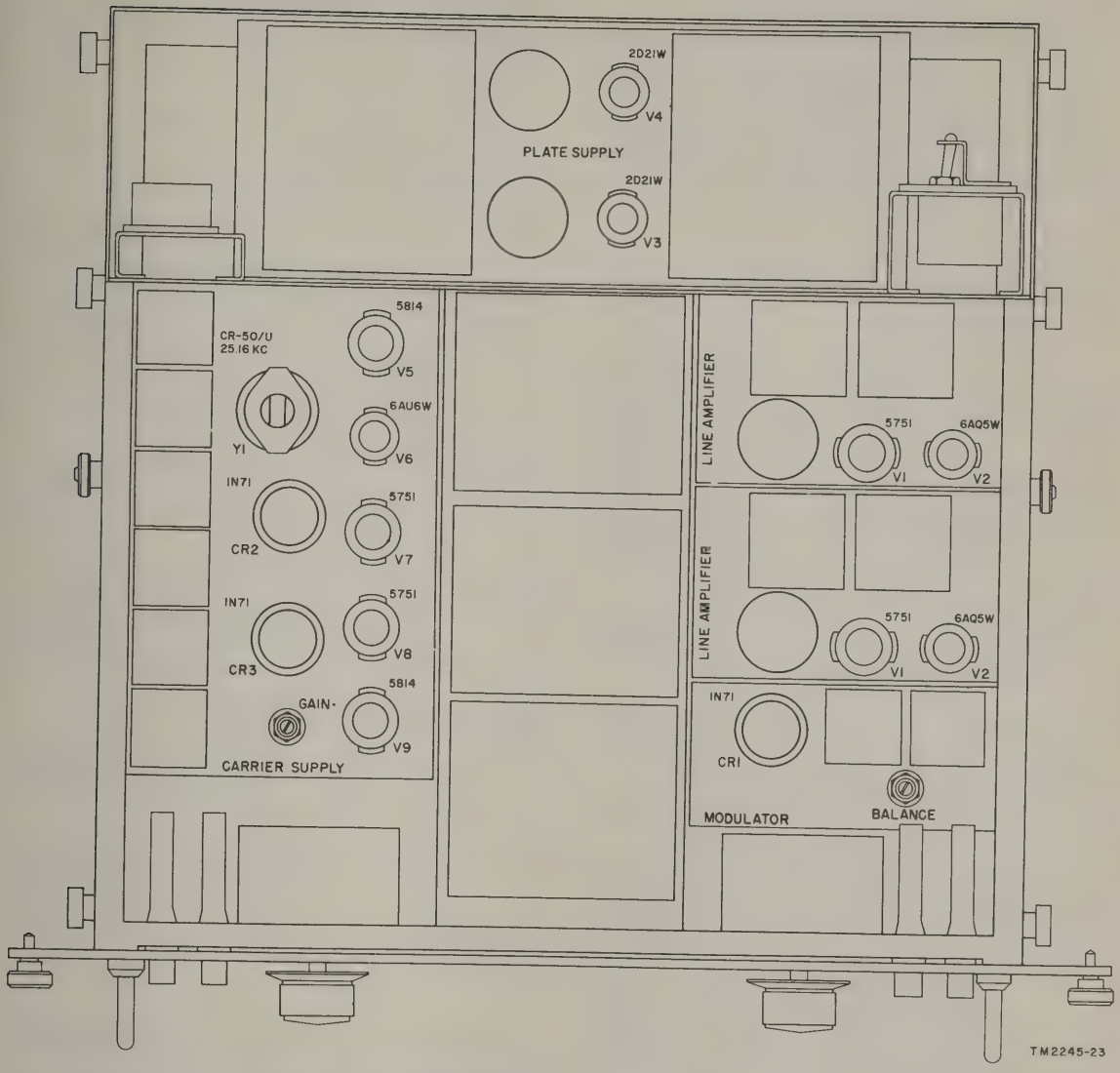



*Figure 64. Demultiplexer TD–98/FGR–3, location of tubes, varistors, crystal, and internal controls.*

*b. Internal Controls.* Controls that are located inside the demultiplexer chassis are shown in figures 60 and 64. The controls and their functions are listed in the chart below.

| Controls | Functions |
|---|---|
| A C POWER 115V–230V switch. | Permits operation on 115 volts or 230 volts ac power when set in appropriate position. |
| BALANCE control | Rotation adjusts carrier leak at output of modulator to a minimum. |
| GAIN control | Rotation adjusts output level of carrier supply. |

## 73. 3KC RECEIVE BAND TEST PANEL Controls

(fig. 65)

The controls of the 3KC RECEIVE BAND TEST PANEL consist of 32 jack pairs arranged on the front panel in three groups. The large center groups of jack pairs are permanently connected into the 3-kc band signal paths of the receiving terminal. The two groups of jack pairs at each end of the panel are available for use as general purpose trunks. The jacks and their functions are described in the chart below.

| Controls | Functions |
|---|---|
| JACK GROUP 1 through JACK GROUP 8, LINE OUT jacks. | Permit measurement of incoming signal levels of vf circuits.<br>Permit incoming signals to be connected to different vf circuits. |
| JACK GROUP 1 through JACK GROUP 8, EQUIP. IN jacks. | Provide means for connecting to 3-kc band receiving vf circuits.<br>Permit test signals to be connected to 3-kc band receiving vf circuits. |
| JACK GROUP 1 through JACK GROUP 8, MONITOR jacks. | Provide means for making bridging connections to 3-kc band circuits in receiving terminal.<br>Permit monitoring of 3-kc band circuits in receiving terminal with high impedance meter or headset without interrupting traffic. |
| TRUNKS 1 through 8 jacks. | Connect to signal distribution terminal boards in top rear of cabinet.<br>Permit connection to test circuits or other trunks for operational and maintenance purposes. |

## 74. TRANSMITTER METER PANEL Controls

*a. Front Panel Controls.* The controls that appear on the front panel of the TRANSMITTER METER PANEL are shown in figure 66. Fuses and blown fuse indicators are located at the left of the panel. When a fuse blows its associated indicator glows. The controls and their functions are listed in the chart below.

| Controls | Functions |
|---|---|
| LEVEL METER | Vu meter used to measure signal levels. |
| BRIDGING jacks | Provide a 14,000-ohm bridging connection to the input circuits of the LEVEL METER circuit. |
| TERMINATING jacks. | Provide a 400-ohm terminating connection to the input circuits of the LEVEL METER circuit. |
| ATTENUATOR control. | Rotation of knob adjusts sensitivity of LEVEL METER circuit. Clockwise rotation decreases sensitivity. |
| DOTTER OUTPUT jack. | Provides means for connecting to output circuits of DOTTER.<br>Permits DOTTER output signals to be connected to transmitter input circuit. |
| METER jack | Provides means for connecting LOOP CURRENT METER into DOTTER output circuit.<br>Permits monitoring of transmitter loop current while DOTTER is in use. |
| MARK-SPACE-DOT. | Permits selection of DOTTER output signals.<br>MARK position provides marking signal at output of DOTTER.<br>SPACE position provides spacing signal at output of DOTTER.<br>DOT position provides dotting signal at output of DOTTER. |
| DOT FREQUENCY indicator. | Indicates type of DOTTER output signal.<br>Glows continuously for marking signal.<br>Does not glow for spacing signal.<br>Glows intermittently at 25 or 30 cps for dotting signal. |
| ON-OFF power switch. | Provides means for connecting 115 volts ac to LEVEL METER and DOTTER circuits. |
| PWR IND | Glows when ac power is being supplied to LEVEL METER and DOTTER circuits. |

| Controls | Functions |
|---|---|
| LOOP CURRENT METER. | Dc millameter used to measure current in dc loop circuits. |
| INPUT jack | Provides means for connecting to LOOP CURRENT METER circuit. |
| MILLIAMPERES switch. | Permits selection of two different full scale values of LOOP CURRENT METER.<br>30 position arranges meter circuit for full scale value of 30 ma.<br>90 position arranges meter circuit for full scale value of 90 ma. |
| BIAS switch | Operation of momentary switch doubles sensitivity of LOOP CURRENT METER for bias measurement. |

*b. Internal Controls.* One control is located on the TRANSMITTER METER PANEL chassis and is shown in figure 67. This control and its function is described below.

| Controls | Functions |
|---|---|
| Level meter adjust control R21. | Rotation adjusts calibration of vu meter reading. |

## 75. RECEIVER METER PANEL Controls

*a. Front Panel Controls.* The controls that appear on the front panel of the RECEIVER METER PANEL are shown in figure 68. Fuses and blown fuse indicators are located near the center of the panel. When a fuse blows, its associated indicator glows. The controls and their functions are listed in the chart below.

| Controls | Functions |
|---|---|
| LEVEL METER | Vu meter used to measure signal levels. |
| BRIDGING jacks | Provide a 14,000-ohm bridging connection to the input circuits of the LEVEL METER circuit. |
| TERMINATING jacks. | Provide a 600-ohm terminating connection to the input circuits of the LEVEL METER circuit. |
| ATTENUATOR control. | Rotation of knob adjusts sensitivity of LEVEL METER circuit. Clockwise rotation decreases sensitivity. |
| ON-OFF power switch. | Provides means for connecting 230 volts ac to LEVEL METER circuit. |
| PWR IND | Glows when ac power is being supplied to LEVEL METER circuit. |
| LOOP CURRENT METER. | Dc milliameter used to measure current in dc loop circuits. |
| INPUT jack | Provides means for connecting to input circuit of LOOP CURRENT METER circuit. |
| 90 MA–30 MA switch. | Permits selection of two different full scale values of LOOP CURRENT METER.<br>30 MA position arranges meter circuit for full scale value of 30 ma.<br>90 MA position arranges meter circuit for full scale value of 90 ma. |
| BIAS switch | Operation of momentary switch doubles sensitivity of LOOP CURRENT METER for bias measurement. |
| DELAY ADJUST METER. | Microammeter used to indicate sense of delay difference between two received signals. |
| ODD CHANNEL input jack. | Provides means for connecting odd-numbered channel signals to input circuit of DELAY ADJUST METER circuit. |
| EVEN CHANNEL input jack. | Provides means for connecting even-numbered channel signals to input circuit of DELAY ADJUST METER circuit. |
| DELAY-BALANCE switch. | Provides means for selecting function of DELAY ADJUST METER.<br>BALANCE position arranges circuit to indicate differences in marking loop currents.<br>DELAY position arranges circuit to indicate differences in delay. |
| BALANCE SENSITIVITY. | Operation of momentary switch increases sensitivity of DELAY ADJUST METER when DELAY-BALANCE switch is set in BALANCE position. |
| LOOP CURRENT switch. | Provides means for connecting odd- or even-numbered channel to LOOP CURRENT METER circuit.<br>ODD CHANNEL position connects odd channel input to LOOP CURRENT METER circuit.<br>EVEN CHANNEL position connects even channel input to LOOP CURRENT METER circuit. |

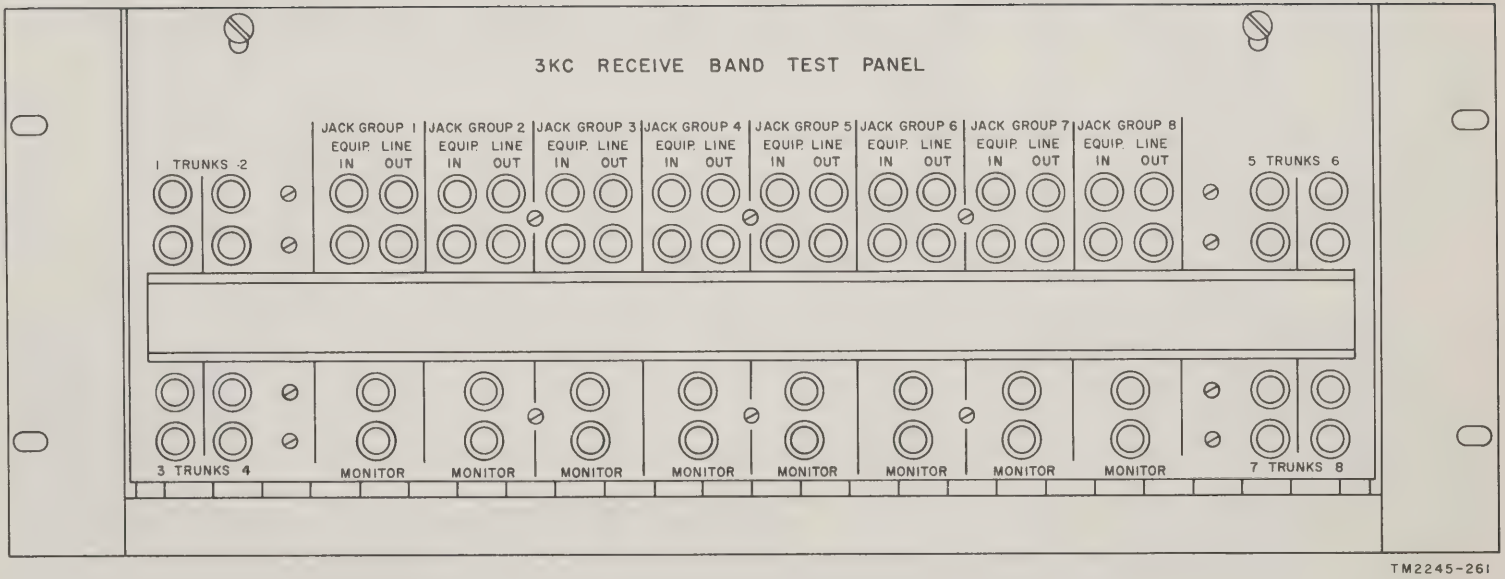



*Figure 65. 3KC RECEIVE BAND TEST PANEL, front panel controls.*

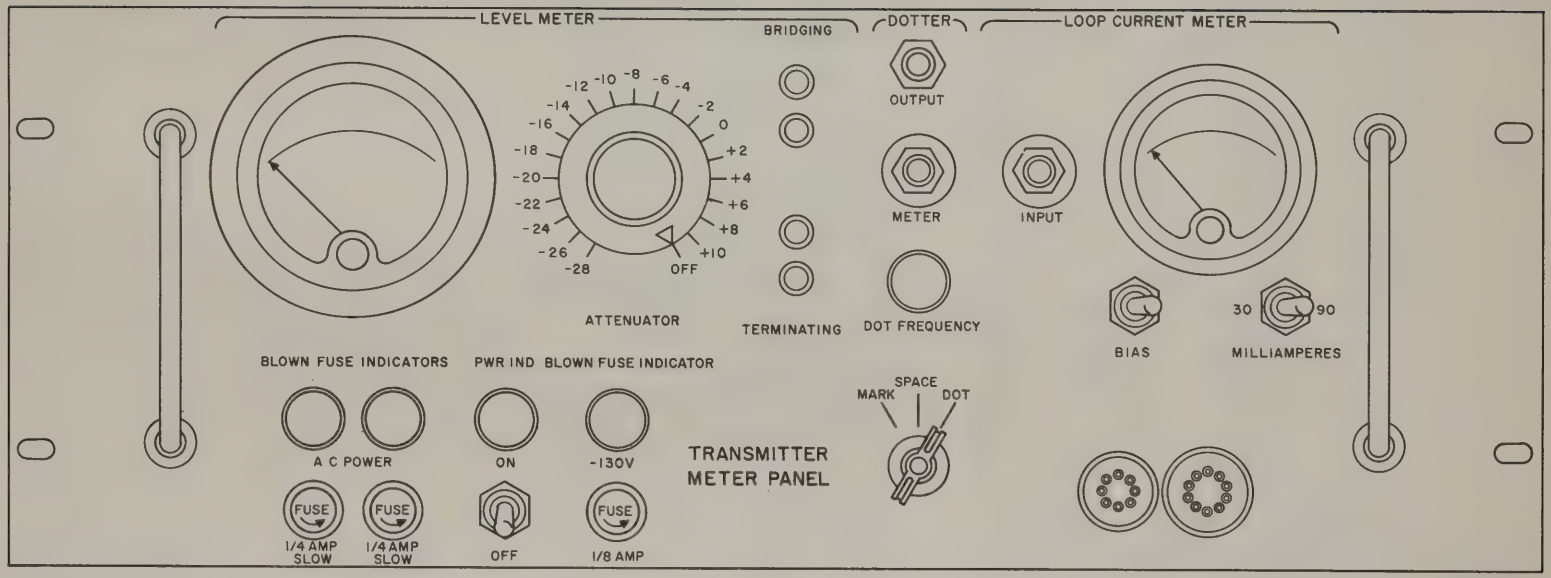



*Figure 66. TRANSMITTER METER PANEL, front panel controls.*

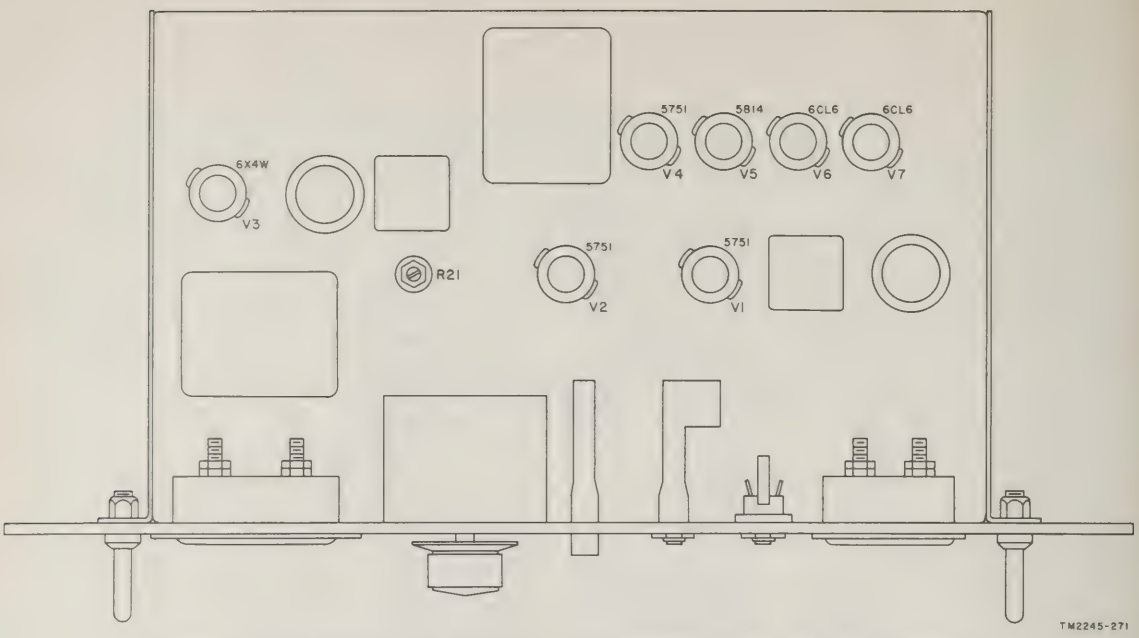



*Figure 67. TRANSMITTER METER PANEL, location of tubes and internal controls.*

*b. Internal Controls.* One control is located on the RECEIVER METER PANEL chassis and is shown in figure 69. This control and its function is described below.

| Controls | Functions |
|---|---|
| Level meter adjust control R21. | Rotation adjusts calibration of vu meter reading. |

## 76. DIVERSITY ALIGNMENT PANEL Controls

All controls in the DIVERSITY ALIGNMENT PANEL appear on the front panel and are shown in figure 70. Figure 71 shows the location of tubes. Fuses and blown fuse indicators are located to the right of the panel. When a fuse blows, its associated indicator glows. The controls and their functions are listed in the chart below.

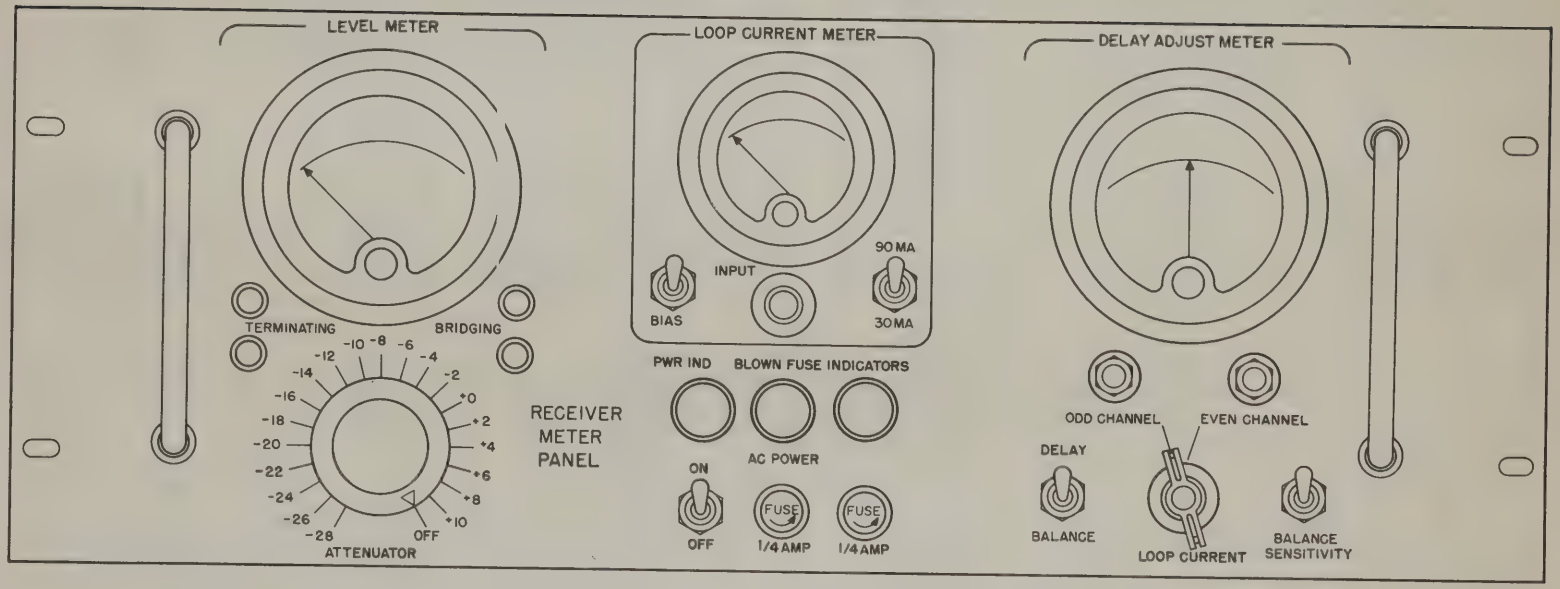



*Figure 68. RECEIVER METER PANEL, front panel controls.*

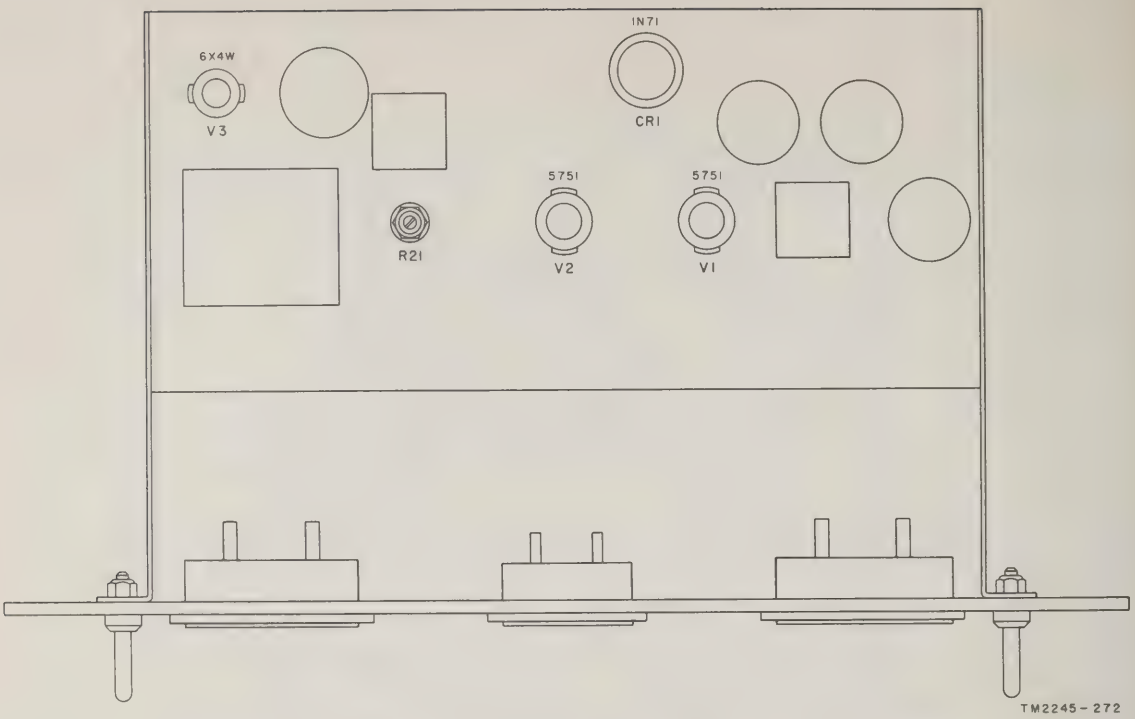



*Figure 69. RECEIVER METER PANEL, location of tubes and internal control.*

| Controls | Functions |
|---|---|
| INPUT ODD NO. CHAN. jacks. | Provide means for connecting odd-numbered channel signals from transmitter to input of diversity alignment circuit. |
| INPUT EVEN NO. CHAN. jacks. | Provide means for connecting even-numbered channel signals from transmitter to input of diversity alignment circuit. |
| COMMON ATTENUATOR switch. | Permits insertion of indicated attenuation in db in both odd channel and even channel inputs of diversity alignment circuit. |
| OUTPUT ON-OFF switches. | Provide means for disconnecting output signals from OUTPUT jacks. |
| | Each of four switches operate with jacks directly below it. |
| | ON position connects output signals to associated OUTPUT jacks. |
| | OFF position disconnects output signals from associated OUTPUT jacks. |
| ODD NUMBERED CHANNEL RECEIVER A OUTPUT jacks. | Permit connection to output of diversity alignment circuit. |
| | Permit patching output to RECEIVER A of odd-numbered channel. |
| ODD NUMBERED CHANNEL RECEIVER B OUTPUT jacks. | Permit connection to output of diversity alignment circuit. |
| | Permit patching output to RECEIVER B of odd-numbered channel. |
| EVEN NUMBERED CHANNEL RECEIVER A OUTPUT jacks. | Permit connection to output of diversity alignment circuit. |
| | Permit patching output to RECEIVER A of even-numbered channel. |
| EVEN NUMBERED CHANNEL RECEIVER B OUTPUT jacks. | Permit connection to output of diversity alignment circuit. |
| | Permit patching output to RECEIVER B of even-numbered channel. |
| BRANCHING NETWORK. | Three-way, 600-ohm, balanced pad that provides two outputs from one input. |
| BRANCHING NETWORK IN jacks. | Permit connection to input circuit of BRANCHING NETWORK. |
| BRANCHING NETWORK OUT 1 jacks. | Permit connection to output 1 of BRANCHING NETWORK. |
| BRANCHING NETWORK OUT 2 jacks. | Permit connection to output 2 of BRANCHING NETWORK. |

| Controls | Functions |
|---|---|
| POWER switch | Provides means for connecting 115 volts ac to diversity alignment circuit. |
| POWER INDICATOR. | Glows when ac power is being supplied to diversity alignment circuit. |

## 77. Main Power Unit Controls

The controls that appear on the front panel of the main power unit are shown in figure 72. The fuses and blown fuse indicators are located on the right side of the panel. When a fuse blows, its associated indicator glows. This control and its function is described below.

| Control | Function |
|---|---|
| ON-OFF switch | Appropriate setting turns primary ac power to associated ac power distribution circuits on or off. |

## 78. AC POWER SWITCHING PANEL Controls

All controls on the AC POWER SWITCHING PANEL are located on the front panel as shown in figure 73. The 230V AC REGULATOR INPUT fuses and their associated BLOWN FUSE INDICATORS appear at the left of the OUTPUT VOLTAGE meter. When a fuse blows its associated indicator glows. The 115V AC UTILITY fuses and their associated BLOWN FUSE INDICATORS appear at the right of the meter. The controls and their functions are listed in the chart below.

| Controls | Functions |
|---|---|
| VOLTAGE REGULATOR switch. | Appropriate setting turns 230 volt ac power to voltage regulator on or off. |
| OUTPUT VOLTAGE switch. | Permits selection of regulated or unregulated power for distribution to associate circuits.<br>REG position connects ac power distribution circuit to output of voltage regulator.<br>UNREG position disconnects ac power distribution circuit from voltage regulator and connects it to unregulated 230 volt ac power. |
| OUTPUT VOLTAGE meter. | Ac voltmeter monitors output voltage of AC POWER SWITCHING PANEL applied to ac power distribution circuit. |
| 115V AC UTILITY OUTLETS. | Provide power for test or maintenance apparatus not requiring more than 300 watts of power. |

## 79. Voltage Regulator Controls

The controls in the voltage regulator appear at the left front surface of the regulator chassis, which is located on the floor of the cabinet behind the cover panel. These controls and their functions are described in the table below and shown in figure 74. The fuse protecting the control circuits from overload appears at the right front surface. The power switch and its associated fuses and blown fuse indicators for the voltage regulator appear on the AC POWER SWITCHING PANEL and are discussed in paragraph 78.

| Controls | Functions |
|---|---|
| 50~–60~ switch S1 | Appropriate setting of switch permits operation of voltage regulator on either 50 or 60 cps ac power. |
| VOLTS ADJ control. | Rotation adjusts output voltage of regulator. |

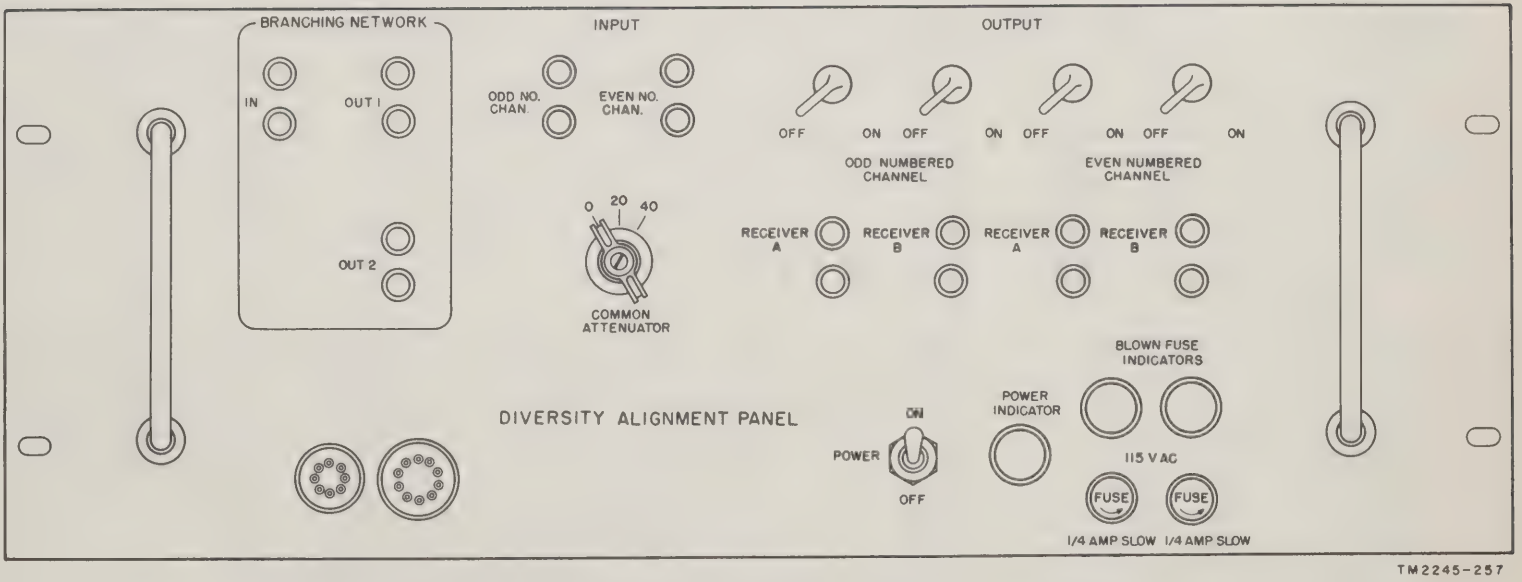



*Figure 70. DIVERSITY ALIGNMENT PANEL, front panel controls.*

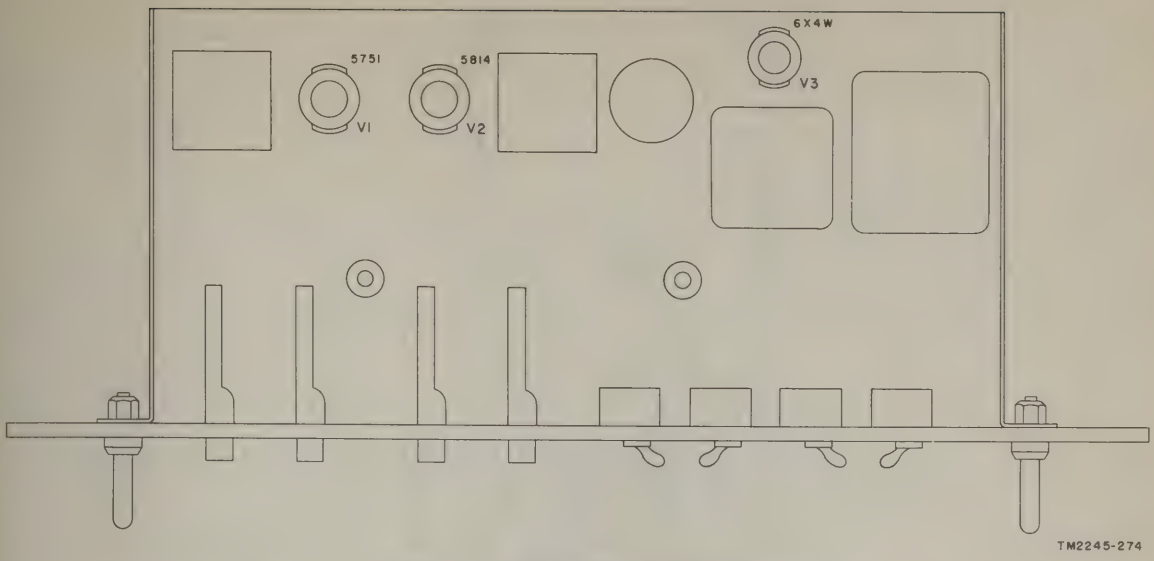



*Figure 71. DIVERSITY ALIGNMENT PANEL, location of tubes.*

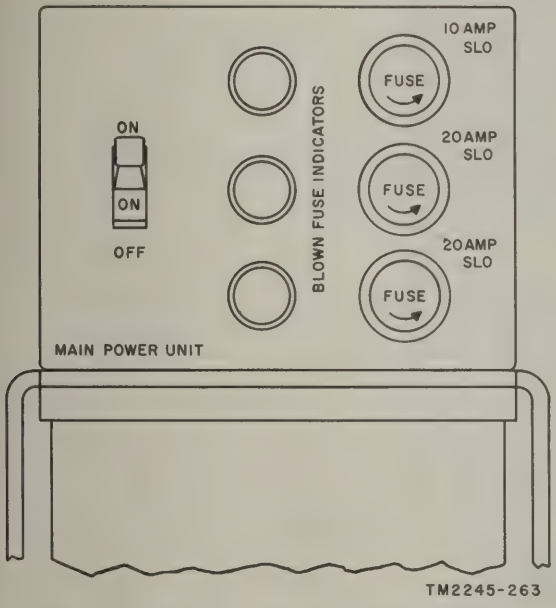



*Figure 72. Main power unit, front panel controls.*

## 80. LOOP BATTERY PANEL Controls

*a. Front Panel Controls.* The controls that appear on the front panel of the LOOP BATTERY PANEL are shown in figure 75. The 16 loop fuses (LOOP FUSES ½ AMP) and their associated BLOWN FUSE INDICATORS are arranged across the top of the panel in two groups. The group to the left serves LOAD A (LOOPS 1–8). The group to the right serves LOAD B (LOOPS 9–16). The power INPUT FUSES and their associated BLOWN FUSE INDICATORS are located at the sides of the panel in two groups. Those on the left serve RECTIFIER A and those on the right serve RECTIFIER B. When a fuse blows its associated blown fuse indicator glows. The controls and their functions are discussed in the chart below.

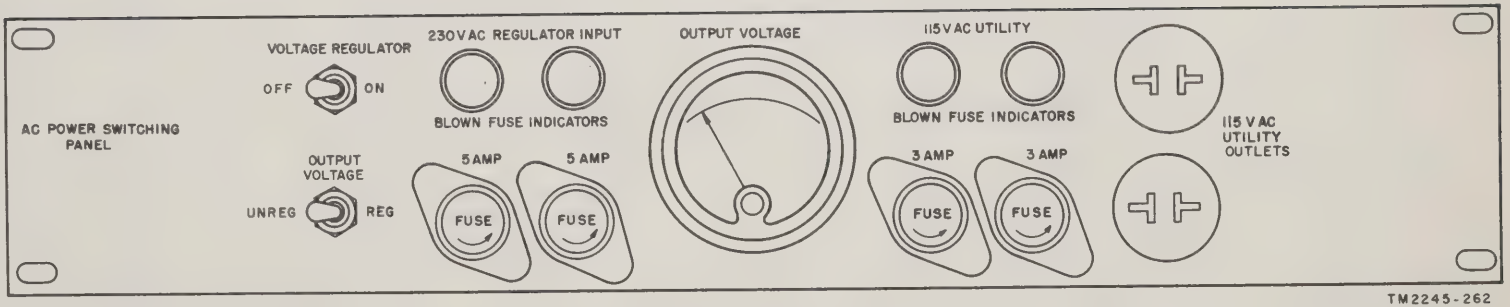



*Figure 73. AC POWER SWITCHING PANEL, front panel controls.*

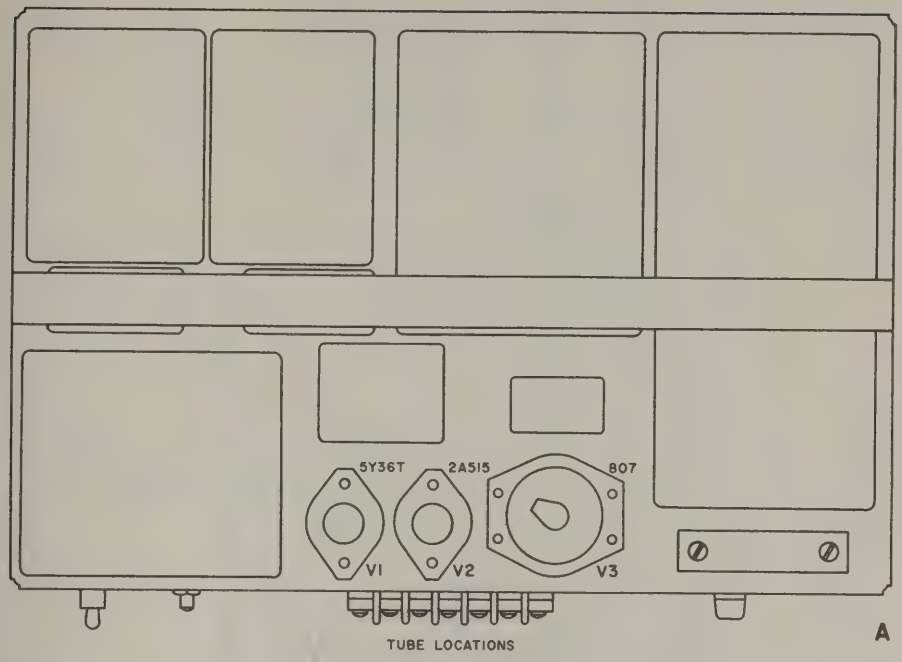



*Figure 74. Voltage regulator, location of tubes and controls.*

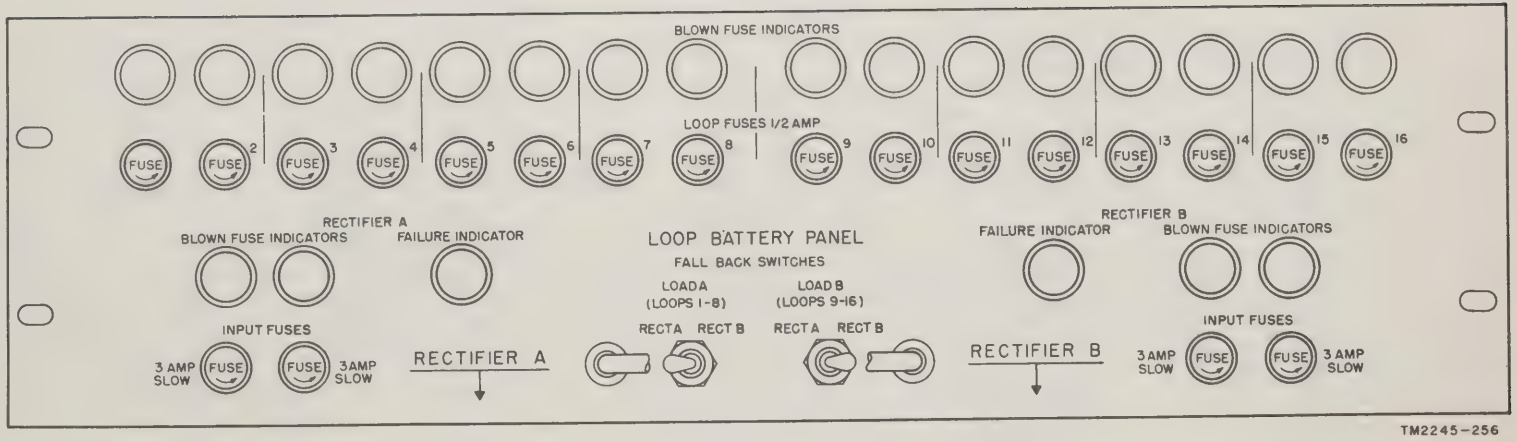



*Figure 75. LOOP BATTERY PANEL, front panelcontrols.*

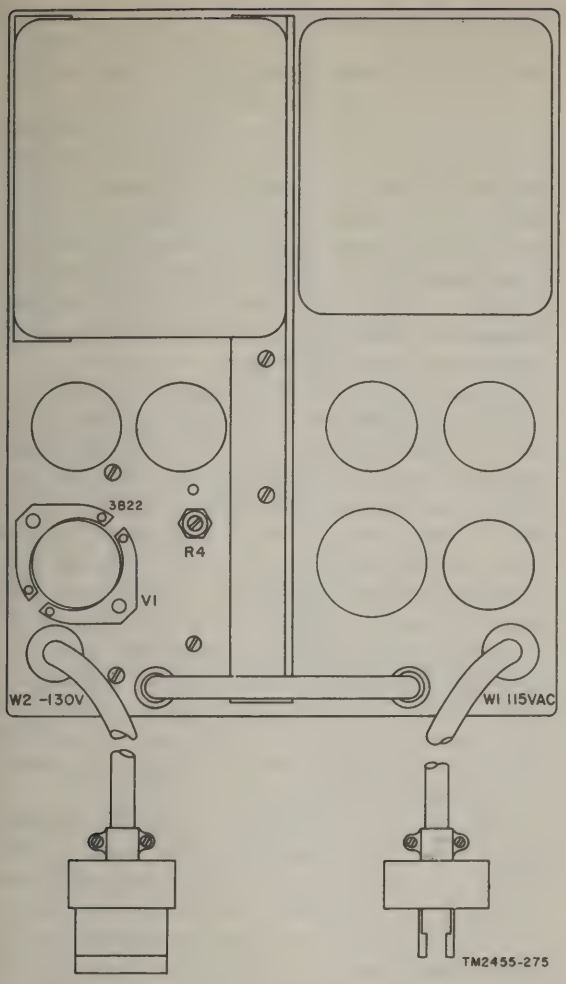



*Figure 76. Loop battery supply, location of tube and control.*

| Controls | Functions |
|---|---|
| LOAD A (LOOPS 1–8) fall back switch. | Provides means for switching loops 1 through 8 to alternate rectifier in the event of failure.<br>RECT A position connects LOAD A (LOOPS 1–8) to RECTIFIER A.<br>RECT B position connects LOAD A (LOOPS 1–8) to RECTIFIER B. |
| LOAD B (LOOPS 9–16) fall back switch. | Provides means for switching loops 9 through 16 to alternate rectifier in the event of failure.<br>RECT A position connects LOAD B (LOOPS 9–16) to RECTIFIER A.<br>RECT B position connects LOAD B (LOOPS 9–16) to RECTIFIER B. |
| RECTIFIER A FAILURE INDICATOR. | Glows when RECTIFIER A fails. |
| RECTIFIER B FAILURE INDICATOR. | Glows when RECTIFIER B fails. |

*b. Internal Controls* (fig. 76). The internal controls associated with the LOOP BATTERY PANEL appear on the loop battery supply chassis that is located on the floor of the cabinet behind the cover panel directly below the LOOP BATTERY PANEL. One control appears on each rectifier chassis as described below.

| Controls | Functions |
|---|---|
| Time delay control R4. | Rotation adjusts time delay for operation of relay K1 in associated rectifier. |

## 81. Blower Motor Controls

Fuses for the blower motor input are located in the power panel (fig. 244) at the rear of the cabinet. The corresponding blown fuse indicators are located on the cover panel (fig. 168) at the front of the same cabinet. When a fuse blows, its associated indicator glows.

## 82. General

The initial adjustments and tests of the AN/FGC–29 terminal covered in this section are made following the installation of the equipment to insure that all components are in proper operating condition. Perform all tests in the sequence given. The preliminary starting procedure is discussed in paragraph 83 and the starting procedure in paragraph 84. The initial adjustments and tests for the various components of the AN/FGC–29 terminal are described in paragraphs 85 through 94. If an abnormal indication is obtained on any component during these adjustments and tests, refer to the troubleshooting procedure in chapter V for the corrective measures to be taken. At the completion of these tests the AN/FGC–29 terminal is ready for performance of the equipment line-up procedure covered in paragraphs 95 through 106.

***Caution:*** When connecting test instruments to front panel MONITOR jacks of the AN/FGC–29 terminal using cords equipped with either single or twin plugs, always make connection first to the test instrument and then to the jacks of the circuit under test. This procedure is essential when using MONITOR jacks to avoid interruption of operating circuits. When using cords equipped with twin plugs for patching or connecting test equipment to any of the front panel jacks, always insert plugs with the serrated edge uppermost. This is essential with unbalanced circuits to avoid shorting the signal path.

## 83. Preliminary Starting Procedure for AN/FGC–29 Terminal

Perform the preliminary operations listed in *a* through *m* below before starting the AN/FGC–29 terminal (par. 84). It is assumed that the AN/FGC–29 terminal has been properly installed as described in paragraphs 45 through 57.

*a.* Check to see that all signal power cables are properly connected to the rear of the units in each cabinet (par. 49). Check to see that the cable to the BLOWER MOTOR BLOWN FUSE INDICATORS in each cabinet is properly connected (fig. 168). The BLOWN FUSE INDICATORS are mounted on the front cover panels at the bottom of each cabinet. The cable connection is made accessible by removing the front cover panel that is held in place by four captive thumb screws.

*b.* Check to see that all tubes, varistors, and crystals of the units in each cabinet are firmly seated in their sockets and that all tube shields and tube and crystal retainers are in place.

*c.* Check to see that the AC POWER switches located on the rear of the multiplexers, demultiplexers, or audio frequency amplifiers in the AN/FGC–29 terminal (fig. 60) are set in the 115V positions. To reset the switches take off the switch guard by removing the screws that hold it in place; then set the switch in the 115V position. Replace the guard and make sure that it is not possible to operate the switch.

*d.* There are three main power units in the AN/FGC–29 terminal (one each in cabinets 1, 3, and 5). Check to see that the ON-OFF switch of each main power unit is in the OFF position. In each main power unit, an adjustable tap on the power transformer permits operation with a primary power source of 107, 115, 122, 210, 230, or 250 volts ac at 50 or 60 cps. Check to see that the tap connection on each transformer agrees with the primary power available (par. 51). To do this, removed the cover plate on the main power unit exposing the transformer taps. Make sure that the tap lug is correctly connected and that the nut is firmly tightened. Replace the cover of the main power unit.

*e.* Be sure that the 50∼–60∼ switches on each of the three voltage regulators (one each in cabinets 2, 4, and 6) are in the proper position to correspond to the frequency of the primary power source (fig. 35). The voltage regulators are located behind the cover panel of the cabinets. To reset the switch, take off the switch guard by removing the screw that holds it in place; then set the switch to the proper position. Replace the guard and make sure that it is not possible to operate the switch.

*f.* Set the switches (fig. 73) on each AC POWER SWITCHING PANEL (one each in cabinets 2, 4, and 6) to the following positions.

(1) Set the OUTPUT VOLTAGE switch to the UNREG position.

(2) Set the VOLTAGE REGULATOR switch to the ON position.

*g.* Set the FALL BACK SWITCHES (fig. 75) on each LOOP BATTERY PANEL (one each in cabinets 1 and 3) to the following positions.

(1) Set LOAD A (LOOPS 1–8) switch to the RECT A position.

(2) Set LOAD B (LOOPS 9–16) switch to the RECT B position.

*h.* Set the switches and controls (fig. 49) on the LEVEL CONTROL & PLATE SUPPLY (cabinet 2) to the following positions.

(1) Set AMPLIFIER IN USE switch to the A position.
(2) Set CHANNELS 1–8 & AMPL A ON POWER SUPPLY switch to the A position.
(3) Set CHANNELS 9–16 & AMPL B ON POWER SUPPLY switch to the B position.
(4) Set the LEVEL ADJUST control to the extreme counterclockwise position (O).

*i.* Set the switches and controls of all transmitters (cabinet 2) to the following positions (fig. 44 and 45).

(1) Set both LOOP CURRENT SELECTOR switches (fig. 45) to the 60MA position.
(2) Set both LOOP TERMINATION switches to the GRD position.
(3) Set both IDLE-NORMAL switches (fig. 44) to the NORMAL position.
(4) Set both LOOP CURRENT ADJUST controls to the extreme counterclockwise position.
(5) Set the DIVERSITY switch to the 2-CHANNEL LOOPS 1 and 2 position.

*Note.* All external telegraph loops to the transmitting terminal must be closed to ground and must not include any external telegraph equipment.

*j.* Set the switches and controls of all combiners (cabinets 4, 5, and 6) to the following positions (figs. 55 and 56).

(1) Set both LOOP CURRENT switches (fig. 56) to the 60MA position.
(2) Set both DISCRIMINATOR switches to the NORMAL position.
(3) Set the DIVERSITY switch (fig. 55) to the 2-CHANNEL LOOPS 1 and 2 position.
(4) Set both IDLE-NORMAL switches to the IDLE position.
(5) Set both LOOP CURRENT ADJUST controls to the extreme counterclockwise positions.

*Note.* All external dc telegraph loops from the receiving terminal must be closed to ground and must not include any external telegraph equipment.

*k.* If the particular system application requires that multiplexers (fig. 58) and demultiplexers (fig. 63) be used in the AN/FGC–29 terminal, they will be located in cabinets 1 and 3, respectively. Set the LEVEL ADJUST controls of these components to the extreme counterclockwise (0) position.

*l.* Set the LEVEL ADJUST controls of the audio frequency amplifiers (fig. 61) in cabinet 3 to the extreme counterclockwise (0) position.

*m.* Set the power ON-OFF switch of the TRANSMITTER METER PANEL (fig. 66) in cabinet 1, RECEIVER METER PANEL (fig. 68) in cabinet 5, and DIVERSITY ALIGNMENT PANEL (fig. 70) in cabinet 3 in the OFF position.

## 84. Starting Procedure for AN/FGC–29 Terminal

Upon completion of the preliminary starting procedure (par. 83) perform the operations listed in *a* through *f* below to start the AN/FGC–29 terminal. If an abnormal indication is obtained during the starting procedure, refer to the troubleshooting procedure in chapter V for the corrective measures to be taken.

*a.* Switch on power at each main power unit (at the bottom rear of cabinets 1, 3, and 5) by operating the ON-OFF switch to the ON position.

*b.* Observe that the blower motors start and that tube heaters are lighted and allow a few minutes to let the equipment warm up.

*c.* Observe the BLOWN FUSE INDICATORS on the front panels of the units, and look for blown fuses. Before replacing blown fuses refer to the troubleshooting procedure for the associated unit for the corrective measures to be taken.

*d.* Observe that the OUTPUT VOLTAGE meter (fig. 73) on each AC POWER SWITCHING PANEL (cabinets 2, 4, and 6) reads 230 volts ac $\pm 10$ volts. Now operate each OUTPUT VOLTAGE switch to the REG position. If necessary, adjust VOLTS ADJ resistor R16 of the voltage regulators (fig. 74) in cabinets 2, 4, and 6 until the reading of the OUTPUT VOLTAGE meter on the corresponding AC POWER SWITCHING PANEL is exactly 230 volts ac.

*e.* Check to see that all of the blower motors are operating properly.

*f.* Measure the loop battery voltages in the transmitting and receiving terminal with multimeter TS–352/U. Make the measurements for the transmitting terminal in cabinet 2 between ground and terminals 1 through 10 of terminal

board TB107 and terminals 1 through 6 of terminal board TB108. Make the measurements for the receiving terminal between ground and terminals 1 through 6 of terminal board TB107 in cabinet 4, terminals 7 through 10 of terminal board TB107 in cabinet 5, and terminals 1 through 6 of terminal board TB108 in cabinet 6. All loop battery potentials should be −130 volts dc ±10 volts with respect to ground.

## 85. Initial Adjustments and Tests for TRANSMITTER METER PANEL

Before the TRANSMITTER METER PANEL can be used as a testing instrument it must first be checked to assure proper operation. The testing procedure for the LEVEL METER circuit is given in *a* below, for the LOOP CURRENT METER circuit in subparagraph *b* below, and for the DOTTER circuit in *c* below.

*Note.* The LEVEL METER reads signal levels in dbm. It is calibrated to read in vu which are applicable when the meter is used to measure speech or other audio signals. Dbm and vu are numerically equal for telegraph or facsimile signals and for a signal test tone.

*a.* Check the LEVEL METER circuit with Signal Generator SG–15/PCM as follows:

(1) Adjust the frequency of the signal generator to 2,000 cps and connect its OUTPUT jacks to the TERMINATING jacks of the LEVEL METER.

(2) Adjust the signal generator level for an output of exactly 0 dbm.

(3) Set the ATTENUATOR control of the LEVEL METER (fig. 66) to 0 and the power ON-OFF switch of the TRANSMITTER METER PANEL to ON. Allow a few moments for the equipment to warm up.

(4) The LEVEL METER should read 0 dbm. If necessary, adjust variable resistor R21 (fig. 67) of the TRANSMITTER METER PANEL to make the reading exactly 0 dbm.

*b.* Check the LOOP CURRENT METER circuit with Multimeter TS–352/U, using the 0–100 ma dc scale, as follows:

(1) Set the MILLIAMPERES switch of the LOOP CURRENT METER to the 90 position (fig. 66) and connect its INPUT jack to the LOOP 1 MONITOR jack of TRANSMITTER CHANNELS 1 and 2.

(2) Set the LOOP CURRENT SELECTOR switch of transmitter channel 1 on 60MA and the LOOP TERMINATION switch on GRD (fig. 45). Connect the multimeter to the LOOP 1 EQUIP jack.

(3) Vary the CHANNEL 1 LOOP CURRENT ADJUST control (fig. 44) of the transmitter until the multimeter reads exactly 60 ma. The LOOP CURRENT METER should read 60 ma ±3 ma on the 90 ma scale.

(4) Set the LOOP CURRENT SELECTOR switch of transmitter channel 1 to the 20MA position and vary the CHANNEL 1 LOOP CURRENT ADJUST control until the multimeter reads exactly 20 ma.

(5) Depress the BIAS switch on the LOOP CURRENT METER and hold until a reading is obtained. The meter should read 40 ma ±3 ma on the 90 ma scale.

(6) Release the BIAS switch and set the MILLIAMPERES switch to the 30 position. The meter should read 20 ma ±2 ma on the 30 ma scale.

(7) Disconnect all plugs and return the LOOP CURRENT SELECTOR switch of transmitter channel 1 to the 60MA position. Restore the CHANNEL 1 LOOP CURRENT ADJUST control to the extreme counter-clockwise position.

*c.* The DOTTER circuit includes a DOT FREQUENCY indicator operating in conjunction with the MARK-SPACE-DOT switch (fig. 66). In the MARK position of the switch, the indicator glows steadily indicating a marking output signal. In the SPACE position, the indicator is extinguished indicating a spacing output signal. In the DOT position, the indicator flashes at a steady 25 or 30 cps rate to indicate a dotting signal output. Check the DOTTER circuit using the following procedure.

(1) Set the MILLIAMPERES switch on the LOOP CURRENT METER (fig. 66) to the 90 position and connect the INPUT jack to the METER jack of the DOTTER.

(2) Set the LOOP TERMINATION switch (fig. 45) of transmitter channel 1 to NEG.

(3) Turn the MARK-SPACE-DOT switch to the MARK position and connect the DOTTER OUTPUT jack to the LOOP 1 EQUIP jack of the transmitter (fig. 44).

(4) Adjust the CHANNEL 1 LOOP CURRENT ADJUST control of the trans-

mitter (fig. 44) to exactly 60 ma as read on the LOOP CURRENT METER.

(5) Switch the MARK-SPACE-DOT switch to the SPACE position. The LOOP CURRENT METER should read 0 ma.

(6) Switch the MARK-SPACE-DOT switch to the DOT position. The LOOP CURRENT METER should read 30 ma ±3 ma.

(7) Depress the BIAS switch of the LOOP CURRENT METER. The LOOP CURRENT METER should read 60 ma ±1 ma.

(8) Disconnect all plugs and reset the LOOP TERMINATION switch of transmitter channel 1 to the GRD position. Restore the CHANNEL 1 LOOP CURRENT ADJUST control to the extreme counterclockwise position.

## 86. Initial Adjustments and Tests for RECEIVER METER PANEL

Before the RECEIVER METER PANEL can be used as a testing instrument, it first must be checked to assure proper operation. The testing procedure for the LEVEL METER and LOOP CURRENT METER is identical to the procedure for these instruments given in paragraph 85 for the TRANSMITTER METER PANEL. The DELAY ADJUST METER is not used until after performance of the AN/FGC–29 terminal line-up procedure. The testing procedure requires the use of two properly aligned receivers and associated combiner, given in paragraph 103 following the receiving terminal line-up.

## 87. Initial Adjustments and Tests for DIVERSITY ALIGNMENT PANEL

Before using the DIVERSITY ALIGNMENT PANEL to perform testing or alignment procedures on the AN/FGC–29 terminal, perform the tests listed in *a* through *i* below.

*a.* Set the POWER switch to the ON position, the COMMON ATTENUATOR switch to the 0 position, and all OUTPUT OFF-ON switches to the OFF position (fig. 70).

*b.* Connect the OUTPUT jacks of Signal Generator SG–15/PCM to the ODD NO. CHAN. INPUT jacks on the DIVERSITY ALIGNMENT PANEL.

*c.* Set the signal generator frequency at 2,000 cps at a level of −15 dbm.

*d.* Connect the TERMINATING jacks of the LEVEL METER in the RECEIVER METER PANEL to the four OUTPUT jack pairs of the DIVERSITY ALIGNMENT PANEL one pair at a time; turning the appropriate OUTPUT OFF-ON switch momentarily to the ON position to obtain a reading. The reading at each jack pair should be −8 dbm ±1 db.

*e.* Set the COMMON ATTENUATOR switch to the 20 position. The reading at each pair of OUTPUT jacks should be −28 dbm ±1 db.

*f.* Set the COMMON ATTENUATOR switch to the 40 position and increase the level of the signal generator to +5 dbm. The reading at each pair of OUTPUT jacks should be −28 ±1 db.

*g.* Connect the signal generator to the EVEN NO. CHAN. INPUT jacks. The reading at the OUTPUT jack pairs should be −28 ±1 db.

*h.* Connect the OUTPUT jacks of the signal generator to the IN jacks of the BRANCHING NETWORK.

*i.* Connect the TERMINATING jacks of the LEVEL METER (fig. 66) in the TRANSMITTER METER PANEL to the OUT 1 jacks of the BRANCHING NETWORK (fig. 70) and the TERMINATING jacks of the LEVEL METER (fig. 68) in the RECEIVER METER PANEL to the OUT 2 jacks of the BRANCHING NETWORK. Both LEVEL METERS should read −1 dbm ±.5 db.

## 88. Initial Adjustments and Tests for TRANSMITTER CHANNELS 1 and 2 through TRANSMITTER CHANNELS 15 and 16

Perform initial adjustments and tests listed in *a* through *e* below for the transmitters in the AN/FGC–29 terminal.

*a.* Make sure that the LOOP CURRENT SELECTOR switch is in the 60MA position and the LOOP TERMINATION switch in the GRD position. Set the MILLIAMPERES switch of the LOOP CURRENT METER (fig. 66) on the TRANSMITTER METER PANEL in the 90 position and connect the INPUT jack of the LOOP CURRENT METER to the LOOP 1 MONITOR jack of TRANSMITTER CHANNELS 1 and 2 (fig. 44). Vary the CHANNEL 1 LOOP CURRENT ADJUST control until the LOOP CURRENT METER indicates 60 ma.

*b.* Connect the CHANNEL 1 CHANNEL OUTPUT jacks of the transmitter to the TER-

MINATING jacks of the LEVEL METER. The signal level as read on the LEVEL METER should be between −12 and −17 dbm. If necessary, adjust the CARRIER LEVEL control for CHANNEL 1 (fig. 45) to bring the signal level within these limits.

*c.* Insert an open plug into the LOOP 1 EQUIP jack of the transmitter. The LEVEL METER reading should not change more than ±1.5 dbm.

*d.* Repeat the procedure in *a* through *c* above for transmitter channel 2 using the corresponding transmitter jacks and controls.

*e.* Repeat the procedures outlined in *a* through *d* above for TRANSMITTER CHANNELS 3 and 4 through TRANSMITTER CHANNELS 15 and 16.

## 89. Initial Adjustments and Tests for SUBGROUP MODULATOR

Perform the initial adjustments and tests listed in *a* through *o* below.

*a.* Insert open twin plugs into the INPUT EQUIP jacks of the DIRECT PATH and the TRANSLATED PATH.

*b.* Remove crystal Y1 in carrier supply Y1 (fig. 188).

*c.* Measure the voltage between terminals 6 and 4 (ground) on transformer T15 (fig. 185) of converter Z2 in the SUBGROUP MODULATOR with Electronic Multimeter ME–6A/U. Adjust the CARRIER LEVEL control (fig. 48) to obtain a reading of 7.2 volts.

*d.* Measure the voltage between terminals 3 and 4 (ground) on terminal board TB7 of converter Z2 with the electronic multimeter. Adjust the BALANCE control to obtain a minimum reading not exceeding .06 volt.

*e.* Measure the frequency of the converter with the Frequency Meter FR–67/U or Frequency Counter AN/USM–26 connected between terminals 6 and 4 (ground) of transformer T15. The correct frequency is 9,690 cps ±1.5 cps. If the frequency is out of limits, replace crystal Y2 (fig. 183). Record the frequency.

*f.* Insert crystal Y1 (fig. 188).

*g.* Measure the voltage between terminals 1 and 2 (ground) on terminal board TB5 of carrier supply Y1 with the electronic multimeter. Adjust the GAIN control (fig. 48) to obtain a reading of 7.2 volts.

*h.* Measure the voltage between terminals 3 and 4 (ground) on terminal board TB3 of modulator Z1 with the electronic multimeter. Adjust the BALANCE control to obtain a minimum reading not exceeding .04 volt.

*i.* Measure the frequency of the carrier supply with the frequency meter connected between terminals 1 and 2 (ground) on terminal board TB5 of carrier supply Y1. The correct frequency is 6,290 cps ±1 cps. If the frequency is out of limits, replace crystal Y1. Record the frequency.

*j.* The difference between the frequency measured in *e* above (9,690 cps ±1.5 cps) and the frequency measured in *i* above (6,290 cps ±1 cps) must be 3,400 cps ±.5 cps.

*k.* If necessary, select crystals Y1 and Y2 until the frequency tolerances given in *e*, *i*, and *j* above are met.

*l.* Remove the open twin plug from the DIRECT PATH INPUT EQUIP jacks and connect these jacks to the OUTPUT jacks of Signal Generator SG–15/PCM.

*m.* Adjust the output level of the signal generator to +5 dbm and the frequency to 2,400 cps.

*n.* Connect the OUTPUT EQUIP jacks of the SUBGROUP MODULATOR to the TERMINATING jacks of the LEVEL METER. The meter should read −25 dbm ±2 db.

*o.* Replace the open twin plug in the DIRECT PATH INPUT EQUIP jacks and repeat the steps described in *l*, *m*, and *n* above, for the TRANSLATED PATH using the appropriate jacks.

## 90. Initial Adjustments and Tests for LEVEL CONTROL & PLATE SUPPLY

Perform the initial adjustments and tests outlined in *a* through *j* below. Use Signal Generator SG–15/PCM to make these tests.

*a.* Connect the signal generator OUTPUT jacks to the INPUT EQUIP jacks of the LEVEL CONTROL & PLATE SUPPLY (fig. 49).

*b.* Adjust the output level of the signal generator to −10 dbm and the frequency to 1,500 cps.

*c.* Set the LEVEL ADJUST control on the LEVEL CONTROL & PLATE SUPPLY to 20.

*d.* Set the LEVEL METER ATTENUATOR to +10 and connect its TERMINATING jacks to the OUTPUT EQUIP jacks on the LEVEL CONTROL & PLATE SUPPLY. The reading of the LEVEL METER should be 10 dbm ±1 db.

*e.* Change the AMPLIFIER IN USE switch to the B position. The reading of the LEVEL METER should remain at +10 dbm ±1 db.

*f.* Change the CHANNEL 1–8 and AMPL A ON POWER SUPPLY switch to the B position and the CHANNEL 9–16 and AMPL B ON

POWER SUPPLY switch to the A position. The reading on the LEVEL METER should remain at +10 dbm ±1 db.

*g.* Change the AMPLIFIER IN USE switch to the A position. The reading of the LEVEL METER should remain at +10 dbm ±1 db.

*h.* Readjust the level of the signal generator to −40 dbm. Disconnect the signal generator from the INPUT EQUIP jacks and connect it to the SPARE AMPL INPUT jacks. Disconnect the LEVEL METER from the OUTPUT EQUIP jacks and connect it to the SPARE AMPL OUTPUT jacks. The LEVEL METER should read +10 dbm and ±1 db.

*i.* Set the AMPLIFIER IN USE switch to the B position. The LEVEL METER should read +10 dbm ±1 db.

*j.* Disconnect all plugs from the LEVEL CONTROL & PLATE SUPPLY and restore all switches to the positions indicated in paragraph 83*b*.

## 91. Initial Adjustments and Tests for Multiplexer TD–97/FGT–2 and Demultiplexer TD–98/FGR–3

When the multiplexers and demultiplexers are installed as part of the AN/FGC–29 terminal, perform the initial adjustments and tests given in *a* through *c* below.

*a.* Adjust the output level of the carrier supply in the multiplexers, and demultiplexers. To do this, measure the voltage between terminals 1 and 2 (ground) on terminal board TB5 of the carrier supply with Electronic Multimeter ME–6A/U. Adjust the GAIN control (fig. 59 and 64) to obtain a reading of 7.2 volts in each case.

*b.* Adjust the carrier leak at the output of the modulator in each multiplexer and demultiplexer to a minimum. To do this, insert open twin plugs in the TRANSLATED PATH INPUT EQUIP jacks and measure the voltage between terminals 3 and 4 (ground) on terminal board TB3 of the modulator with the electronic multimeter. Adjust the BALANCE control to obtain a minimum reading not exceeding .04 volt.

*c.* Measure the frequency of each carrier supply with Frequency Meter FR–67/U or Frequency Counter AN/USM–26 connected between terminals 1 and 2 (ground) on terminal board TB5 of the carrier supply. The correct frequency is 6,290 cps ±1 cps. If the frequency is out of limits, replace crystal Y1.

## 92. Initial Adjustments and Tests for SUBGROUP DEMODULATOR

Perform the initial adjustments and tests listed in *a* through *g* below on SUBGROUP DEMODULATORS A and B, separately.

*a.* Insert an open twin plug into the INPUT EQUIP jacks (fig. 51).

*b.* Measure the voltage between terminals 6 and 4 (ground) on transformer T15 (fig. 185) of converter Z2 in the SUBGROUP DEMODULATOR with Electronic Multimeter ME–6A/U. Adjust the CARRIER LEVEL control (fig. 52) to obtain a reading of 7.2 volts.

*c.* Measure the voltage between terminals 3 and 4 (ground) on terminal board TB7 of converter Z2 with the electronic multimeter. Adjust the BALANCE control (fig. 52) to obtain a minimum reading not exceeding .06 volt.

*d.* Measure the frequency of the converter with Frequency Meter FR–67/U or Frequency Counter AN/USM–26 connected between terminals 6 and 4 (ground) of transformer T15. The correct frequency is 9,690 cps ±1.5 cps. If the frequency is out of limits, replace crystal Y2 (fig. 183). Record the frequency reading.

*e.* Measure the voltage between terminals 1 and 2 (ground) on terminal board TB5 of carrier supply Y1 with the electronic multimeter. Adjust the GAIN control to obtain a reading of 7.2 volts.

*f.* Measure the voltage between terminals 3 and 4 (ground) on terminal board TB3 of modulator Z1, with the electronic multimeter. Adjust the BALANCE control to obtain a minimum reading not exceeding .04 volt.

*g.* Measure the frequency of the carrier supply with the frequency meter connected between terminals 1 and 2 (ground) of terminal board TB5 of carrier supply Y1. The correct frequency is 6,290 cps ±1 cps. If the frequency is out of limits, replace crystal Y1 (fig. 188).

*h.* The difference between the frequency measured in *d* above (9,690 cps ±1.5 cps) and the frequency measured in *g* above (6,290 cps ±1 cps) must be 3,400 cps ±5 cps.

*i.* If necessary, select crystals Y1 and Y2 until the frequency tolerances given in *d*, *g*, and *h* above are met.

### 93. Initial Adjustments and Tests for RECEIVER CHANNEL 1 through RECEIVER CHANNEL 16

Perform the initial adjustments and tests in *a* through *i* below for the receivers in the AN/FGC–29 terminal. The receiver designations and channel frequencies are given in paragraph 11*d*.

*a*. Set the DELAY ADJ control to the 0 position and the LEVEL ADJ and MON LEVEL ADJ controls (fig. 54) to the extreme clockwise position for both RECEIVER A and RECEIVER B.

*b*. Insert an open circuit twin plug into the RECEIVER B EQUIP jacks (fig. 53).

*c*. Connect the OUTPUT jacks of Signal Generator SG–15/PCM to the RECEIVER A EQUIP jacks. Set the signal generator to the midchannel frequency of the receiver (par. 11*d*) at a level of −8 dbm.

*d*. Connect the LEVEL METER BRIDGING jacks (fig. 68) in the RECEIVER METER PANEL to the RECEIVER A LINE jacks. The LEVEL METER should read −14 dbm ±2 db.

*e*. Connect the LEVEL METER BRIDGING jacks to the RECEIVER A MONITOR jacks. The LEVEL METER should read −6.5 dbm.

*f*. Connect the LEVEL METER BRIDGING jacks to the RECEIVER A METER jacks, and set the METER SWITCH in the A position. The LEVEL METER should read −22 dbm ±2 db.

*g*. Connect Electronic Multimeter ME–6A/U between the OUTPUT and GRD pin jacks on RECEIVER A delay amplifier (fig. 54). The multimeter should read 8.5 volts ±1.5 volts.

*h*. Remove the open circuit plug from the RECEIVER B EQUIP jacks, and insert it into the RECEIVER A EQUIP jacks. Repeat the steps in *c* through *g* above for RECEIVER B; use the appropriate jacks and controls.

*i*. Repeat the steps in *a* through *h* above for RECEIVER CHANNEL 2 through RECEIVER CHANNEL 16.

### 94. Initial Adjustments and Tests for COMBINER CHANNELS 1 and 2 through COMBINER CHANNELS 15 and 16

Perform the initial adjustments and tests in *a* through *e* below for the combiners in the AN/FGC–29 terminal. See that the controls of the combiner are set as indicated in paragraph 83*j*.

*a*. Set the LOOP CURRENT METER 90 MA–30 MA switch in the RECEIVER METER PANEL (fig. 68) to the 90 MA position and connect the LOOP CURRENT METER INPUT jack to the LOOP 1 MONITOR jack (fig. 55) of COMBINER CHANNELS 1 and 2.

*b*. Vary the CHANNEL 1 LOOP CURRENT ADJUST control until the LOOP CURRENT METER reads 60 ma.

*c*. Connect the LOOP CURRENT METER INPUT jack to the LOOP 2 MONITOR jack of the combiner.

*d*. Vary the CHANNEL 2 LOOP CURRENT ADJUST control until the LOOP CURRENT METER reads 60 ma.

*e*. Repeat the steps in *a* through *d* above for COMBINER CHANNELS 3 and 4 through COMBINER CHANNELS 15 and 16.

## Section III. EQUIPMENT LINE-UP PROCEDURE

### 95. General

The AN/FGC–29 terminal is not ready for traffic operation until it has been lined up in accordance with the procedures given in this section. The delay amplifiers in the receivers must be lined up on dotting signals from the distant AN/FGC–29 terminal over the interconnecting radio and wire line circuits. The line-up of the delay amplifiers therefore is covered under the system line-up procedure discussed in paragraphs 107 through 113.

### 96. Line-up Procedure for Telegraph Transmitter Group

This procedure permits the frequencies and levels in the telegraph transmitter group to be checked and, if necessary, readjusted to meet the prescribed requirements. Figure 248 is a block diagram of the transmitting terminal showing the various controls and test points.

*a*. The line-up procedure for transmitter channel 1 of TRANSMITTER CHANNELS 1 and 2 in the steps in (1) through (17) below is given as

a typical example. The procedure for transmitter channels 2 through 16 in (18) below is identical except that the frequencies may be different. The transmitter designations and channel frequencies are given in paragraph 7*c*.

(1) Turn the LOOP TERMINATION switch (fig. 45) in transmitter channel 1 to the NEG position, the IDLE-NORMAL switch (fig. 44) to the NORMAL position, and the DIVERSITY switch to the 2 CHANNEL LOOPS 1 and 2 position. Set the LOOP CURRENT SELECTOR switch to the 60MA position.

(2) Set the IDLE-NORMAL switches of all other transmitter channels in the IDLE position.

(3) Connect the OUTPUT jack on the DOTTER (fig. 66) of the TRANSMITTER METER PANEL to the LOOP 1 EQUIP jack of the transmitter.

(4) Connect the INPUT jack of the LOOP CURRENT METER on the TRANSMITTER METER PANEL to the METER jack on the DOTTER and turn the MARK-SPACE-DOT switch to the MARK position. See that the loop current is between 50 and 60 ma.

(5) Connect Frequency Meter FR–67/U or Frequency Counter AN/USM–26 to the SPARE AMPL OUTPUT jacks on the LEVEL CONTROL & PLATE SUPPLY (fig. 49).

(6) Connect CHANNEL 1 CARRIER MONITOR jacks of the transmitter to the SPARE AMPL INPUT jacks on the LEVEL CONTROL & PLATE SUPPLY. The amplifier is necessary to amplify the carrier signals to the proper level for the frequency meter.

(7) Connect the TERMINATING jacks of the LEVEL METER on the TRANSMITTER METER PANEL to the OUTPUT EQUIP jacks of the LEVEL CONTROL & PLATE SUPPLY and set the LEVEL ADJUST control on this component to 35. Adjust the signal level to −10 dbm by using the CARRIER LEVEL control of transmitter channel 1 (fig. 45).

(8) Read the transmitter marking frequency as shown on the frequency meter. The frequency should be 1,827.5 cps ±1 cps. If the frequency is outside these limits proceed with the instructions in (9) and (10) below to readjust the transmitter marking frequency. If the frequency is correct, proceed with the instructions in (11) below.

(9) To adjust the marking frequency, first tune variable capacitor C10A and C10B (fig. 178). Capacitor C10A and C10B changes the transmitter channel frequencies by approximately 3 cps. Capacitor C10A and C10B is adjusted for minimum frequency when the solder dot on the rotating section lines up with the solder dot on the stationary section. They are at maximum frequency when the dots are 180° apart.

(10) If the marking frequency cannot be brought within limits by variable capacitor C10A and C10B, strap in (or cut out) trimmer capacitor C7, C8, or C9 (figs. 178 and 179) in accordance with the table below. Adding a capacitor listed in the table decreases the frequency by the indicated amount. Removing a capacitor increases the frequency by the indicated amount. These capacitors may be used singly or in combination as required to bring the marking frequency within the range of trimmer capacitor C10A and C10B.

Strapping connections for marking frequency adjustment

| Trimmer capacitor | Strap terminals on terminal board TB4 | Approximate freq change |
|---|---|---|
| C9 | 1 to 9 | 3 cps. |
| C8 | 1 to 6 | 6 cps. |
| C7 | 1 to 3 | 10 cps. |

***Caution:*** Remove ac power and loop battery potential to the transmitter before altering strapping connections or the equipment may be damaged. To do this, disconnect the power and signal connectors from the receptacles at the rear of the component.

(11) Turn the MARK-SPACE-DOT switch to the SPACE position and read the transmitter spacing frequency as shown on the frequency meter. The frequency should be 1,742.5 cps ±1 cps. If the frequency is outside these limits, proceed with the instructions in (12) below to readjust the transmitter spacing fre-

quency. If the frequency is correct, proceed with the instructions in (13) below.

(12) To adjust the spacing frequency strap in (or cutout) trimmer capacitors C11 through C14 (figs. 178 and 179) in accordance with the table below. Adding a capacitor listed in the table decreases the frequency by the indicated amount. Removing a capacitor increases the frequency by the indicated amount. These capacitors may be used singly or in combination as required to bring the spacing frequency within limits.

Strapping connections for spacing frequency adjustment

| Trimmer capacitor | Strap terminals on terminal board TB4 | Approximate freq change |
|---|---|---|
| C14 | 13 to 26 | 0.5 cps. |
| C13 | 13 to 23 | 1 cps. |
| C12 | 13 to 20 | 2 cps. |
| C11 | 13 to 16 | 4 cps. |

(13) Remove the plug from the CHANNEL 1 CARRIER MONITOR jacks. Alternate the MARK-SPACE-DOT switch between MARK and SPACE. The marking and spacing signal levels, as read on the LEVEL METER, should not differ by more than .5 db. If necessary, adjust the transmitter channel 1 S–M EQUALIZER control (fig. 46) to equalize the spacing and marking frequency levels.

(14) Adjustment of the S–M EQUALIZER control may vary the channel frequency slightly. If the S–M EQUALIZER control setting is altered, check the marking and spacing frequencies ((8) and (11) above) and, if necessary, readjust to bring them within the prescribed limits.

(15) Set the MARK-SPACE-DOT switch to DOT and adjust the transmitter channel 1 CARRIER LEVEL control for a reading of exactly −10 dbm on the LEVEL METER.

(16) Remove the cord from the TERMINATING jacks of the LEVEL METER and the OUTPUT EQUIP jacks of the LEVEL CONTROL & PLATE SUPPLY (fig. 49). Connect the BRIDGING jacks of the LEVEL METER to the CHANNEL 1 CARRIER MONITOR jacks of the transmitter. Measure the signal level on the LEVEL METER and record the measurement for future reference.

(17) Disconnect all plugs, reset the transmitter channel 1 LOOP TERMINATION switch to the GRD position and the IDLE-NORMAL switch to the IDLE position.

(18) Repeat the steps in (1) through (17) for above transmitter channels 2 through 16. The marking and spacing frequencies for the various transmitter channels are given in the chart below.

| Transmitter channel | Spacing frequency | Marking frequency | Transmitter channel | Spacing frequency | Marking frequency |
|---|---|---|---|---|---|
| 1 | 1, 742. 5 | 1, 827. 5 | 9 | 2, 422. 5 | 2, 507. 5 |
| 2 | 2, 932. 5 | 3, 017. 5 | 10 | 2, 252. 5 | 2, 337. 5 |
| 3 | 1, 912. 5 | 1, 997. 5 | 11 | 2, 592. 5 | 2, 677. 5 |
| 4 | 2, 762. 5 | 2, 847. 5 | 12 | 2, 082. 5 | 2, 167. 5 |
| 5 | 2, 082. 5 | 2, 167. 5 | 13 | 2, 762. 5 | 2, 847. 5 |
| 6 | 2, 592. 5 | 2, 677. 5 | 14 | 1, 912. 5 | 1, 997. 5 |
| 7 | 2, 252. 5 | 2, 337. 5 | 15 | 2, 932. 5 | 3, 017. 5 |
| 8 | 2, 422. 5 | 2, 507. 5 | 16 | 1, 742. 5 | 1, 827. 5 |

*b.* Perform the following procedures to complete the line-up of the telegraph transmitter group.

(1) Connect the TERMINATING jacks of the LEVEL METER (fig. 66) to the OUTPUT EQUIP jacks of the LEVEL CONTROL & PLATE SUPPLY (fig. 49).

(2) Turn the IDLE-NORMAL switches of all transmitter channels to the NORMAL position. The LEVEL METER should read +2 dbm with random level fluctuations of approximately ±1 db. This is the correct transmitting level for the telegraph transmitter group when operating in space diversity (par. 108*a*(1)(*a*)).

(3) When operating in frequency diversity (par. 108*a*(1)(*b*)), the correct transmitting level, as read on the LEVEL METER, is +8 dbm. To obtain this level, turn the LEVEL ADJUST control of the LEVEL CONTROL & PLATE SUPPLY to position 41.

(4) Disconnect the LEVEL METER from the OUTPUT EQUIP jacks of

the LEVEL CONTROL & PLATE SUPPLY.

## 97. Line-up Procedure for Telegraph Receiver Group, General

(fig. 249)

The line-up procedure for the telegraph receiver group permits signal levels and the tuning of delay amplifiers and discriminators in the telegraph receiver group to be checked, and, if necessary, readjusted to meet the prescribed requirements. A properly aligned telegraph transmitter group (par. 96) is used as a source of signals for lining up the telegraph receiver group. Preliminary line-up adjustments for the telegraph receiver group are given in paragraph 98. The line-up procedure for the receivers is given in paragraph 99 and for the combiners in paragraph 100. First, line up two receivers that can operate in four-channel diversity (RECEIVER CHANNEL 1 and RECEIVER CHANNEL 2 in this example) and then immediately proceed with the line-up of the associated combiner (COMBINER CHANNELS 1 and 2 in this example). When the combiner is lined up, proceed to check the tuning of the delay amplifiers in the two receivers by following the procedure in paragraph 101. After this has been done, line up the remaining channels in the telegraph receiver group by following the procedures in paragraphs 99 through 101; use the appropriate jacks and controls. Perform the line-up check for the subgroup demodulators given in paragraph 102 to complete the line-up of the telegraph receiver group. Figure 249 is a block diagram of the receiving terminal that shows the various controls and test points.

## 98. Preliminary Line-Up Procedure for Telegraph Receiver Group

Perform the following procedures for all combiners before starting the line-up of the receiving terminal.

*a.* See that the switches on the combiners are in the positions indicated in the following table.

| Control | Position |
|---|---|
| DISCRIMINATOR (fig. 56) | NORMAL. |
| LOOP CURRENT (fig. 56) | 60 MA. |
| IDLE-NORMAL (fig. 55) | IDLE. |
| DIVERSITY (fig. 55) | 2 CHANNEL. |

*b.* Be sure that all external loops are closed to ground. Connect the INPUT jacks of the LOOP CURRENT METER on the RECEIVER METER PANEL (fig. 68) to each loop MONITOR jack of the combiners, one at a time, and adjust the loop currents to 60 ma with the corresponding LOOP CURRENT ADJUST control (fig. 55).

## 99. Line-up Procedure for Receivers

The A and B receivers of each receiver channel must be properly aligned with respect to each other and also with respect to the A and B receivers of the receiver channel with which they are interconnected when operating in four-channel diversity (par. 118*b*). The line-up procedure is given for RECEIVER CHANNEL 1 and RECEIVER CHANNEL 2 as a typical example. The procedure for the other receivers is the same.

*a. Preliminary Line-Up Procedure for RECEIVER CHANNEL 1 and RECEIVER CHANNEL 2.*

(1) Set the DIVERSITY switch (fig. 44) in TRANSMITTER CHANNELS 1 and 2 to the 4 CHANNEL LOOP 1 ONLY position.

(2) Set both LOOP CURRENT SELECTOR switches (fig. 45) of the transmitter to the 60MA position.

(3) Set both LOOP TERMINATION switches (fig. 45) of the transmitter to NEG.

(4) Connect the OUTPUT jack of the DOTTER on the TRANSMITTER METER PANEL (fig. 66) to the LOOP 1 EQUIP jack of the transmitter.

(5) Set the MARK-SPACE-DOT switch (fig. 66) to the DOT position.

(6) Connect the CHANNEL 1 CHANNEL OUTPUT jacks of the transmitter (fig. 44) to the INPUT ODD NO. CHAN. jacks on the DIVERSITY ALIGNMENT PANEL (fig. 70). Connect the CHANNEL 2 CHANNEL OUTPUT jacks of the transmitter (fig. 44) to the INPUT EVEN NO. CHAN. jacks on the DIVERSITY ALIGNMENT PANEL.

(7) Turn the COMMON ATTENUATOR switch (fig. 70) to the 0 position.

(8) Connect the RECEIVER A OUTPUT ODD NUMBERED CHANNEL jacks on the DIVERSITY ALIGNMENT

PANEL to the RECEIVER A EQUIP jacks of RECEIVER CHANNEL 1. Connect the RECEIVER B OUTPUT ODD NUMBERED CHANNEL jacks to the RECEIVER B EQUIP jacks of RECEIVER CHANNEL 1. Connect the RECEIVER A OUTPUT EVEN NUMBERED CHANNEL jacks to the RECEIVER A EQUIP jacks of RECEIVER CHANNEL 2. Connect the RECEIVER B OUTPUT EVEN NUMBERED CHANNEL jacks to the RECEIVER B EQUIP jacks of RECEIVER CHANNEL 2.

(9) Set the four DELAY ADJ controls (fig. 54) located on the delay amplifier in RECEIVER CHANNEL 1 and RECEIVER CHANNEL 2 to the extreme counterclockwise (0) positions.

(10) Set the four MON LEVEL ADJ controls of the receivers (fig. 54) to the extreme clockwise positions.

(11) Set the four LEVEL ADJUST controls (fig. 56) of COMBINER CHANNELS 1 and 2 to the extreme counterclockwise positions.

(12) See that the DIVERSITY switch of COMBINER CHANNELS 1 and 2 (fig. 55) is set to the 4-CHANNEL LOOP 1 ONLY position.

*b. Line-up Procedure for RECEIVER CHANNEL 1 and RECEIVER CHANNEL 2.*

(1) Set the OUTPUT switch for RECEIVER A ODD NUMBERED CHANNEL on the DIVERSITY ALIGNMENT PANEL (fig. 70) to the ON position, and set the other three OUTPUT switches to the OFF position.

(2) Connect Electronic Multimeter ME–6A/U to the OUTPUT and GRD pin jacks on the RECEIVER A delay amplifier (fig. 54) of RECEIVER CHANNEL 1.

(3) Set the LEVEL ADJ control on the delay amplifier for a reading of 2.5 volts on the multimeter.

(4) Connect the BRIDGING jacks of the LEVEL METER on the RECEIVER METER PANEL (fig. 68) to the RECEIVER A MONITOR jacks of RECEIVER CHANNEL 1 and record the reading.

(5) Remove the LEVEL METER connections from the MONITOR jacks and connect them to the METER jacks of RECEIVER CHANNEL 1. Set the METER SWITCH to the A position. The meter should read $-22$ dbm $\pm 2$ dbm.

(6) Set the COMMON ATTENUATOR switch (fig. 70) on the DIVERSITY ALIGNMENT PANEL to the 40 position. The LEVEL METER reading should not decrease by more than 2 db.

(7) Repeat the procedures in (1) through (6) above for RECEIVER B of RECEIVER CHANNEL 1 and both receivers of RECEIVER CHANNEL 2. Use the appropriate switches on the DIVERSITY ALIGNMENT PANEL and the correct jacks and METER SWITCH settings on the receiver channels.

(8) Set the COMMON ATTENUATOR switch of the DIVERSITY ALIGNMENT PANEL to the 20 position, the output switch for RECEIVER A ODD NUMBERED CHANNEL to the ON position, and the remaining OUTPUT switches to the OFF position. Connect the BRIDGING jacks of the LEVEL METER (fig. 68) to the METER jacks of RECEIVER CHANNEL 1 and set the METER SWITCH to the A position.

(9) Determine which receiver has the greatest gain by momentarily energizing the other three receivers, one at a time, by using the OUTPUT switches on the DIVERSITY ALIGNMENT PANEL. Note the effect on RECEIVER A of RECEIVER CHANNEL 1 by observing the LEVEL METER reading. The receiver producing the greatest decrease in the LEVEL METER reading has the highest gain. If no reduction is obtained, RECEIVER A of RECEIVER CHANNEL 1 has the highest gain.

(10) Connect the LEVEL METER to the METER jacks of the receiver having the highest gain (METER SWITCH in the appropriate position), and energize the other three receivers, one at a time, with the OUTPUT switches of the DIVERSITY ALIGNMENT PANEL. By means of the associated receiver LEVEL ADJ control, increase the signal level in each of the three receivers to compensate

for the lower gain in these receivers. Proper compensation is indicated by a decrease of approximately .5 db in the LEVEL METER reading when the receiver being compensated is energized.

(11) Set the COMMON ATTENUATOR switch of the DIVERSITY ALIGNMENT PANEL to the 40 position.

(12) Check the compensation of the receivers by noting the effect on the signal level in each receiver when the remaining receivers are energized one at a time. Measure the signal level with the LEVEL METER BRIDGING jacks (fig. 68) connected to the METER jacks (fig. 53) of the particular receiver and with the METER SWITCH set in the appropriate A or B position. Proper compensation is indicated if no decrease greater than 1.5 db in the meter reading of the receiver being observed is obtained when any one of the other receivers is momentarily energized.

(13) Set the COMMON ATTENUATOR switch on the DIVERSITY ALIGNMENT PANEL to the 0 position. Check the compensation of the receivers ((12) above).

(14) Check the levels at the MONITOR jacks of the four receivers with the LEVEL METER connected on a bridging basis. The reading should not differ by more than 3 db from the values recorded in (4) above for the four receivers.

(15) Connect the BRIDGING jacks of the LEVEL METER to the RECEIVER A MONITOR jacks of RECEIVER CHANNEL 1 and energize the receiver. Set the MON LEVEL ADJ control (fig. 54) for a reading of exactly −20 dbm on the LEVEL METER.

(16) Repeat the procedure in (15) above for the RECEIVER B MONITOR jacks of RECEIVER CHANNEL 1 and both pairs of MONITOR jacks for RECEIVER CHANNEL 2; use the appropriate jacks and controls. After the MON LEVEL ADJ controls have been adjusted, do not disturb them unless a complete line up of the receiver channels is made.

## 100. Line-up Procedure for Combiners

After RECEIVER CHANNEL 1 and RECEIVER CHANNEL 2 have been aligned (par. 99), the associated COMBINER CHANNELS 1 and 2 can be lined up. TRANSMITTER CHANNELS 1 and 2 serve as a source of test signals for lining up this combiner. The setup of TRANSMITTER CHANNELS 1 and 2, DIVERSITY ALIGNMENT PANEL, RECEIVER CHANNEL 1, and RECEIVER CHANNEL 2 is left intact as given in paragraphs 99*a*(1) through (9). The line-up procedure for the A path of channel 1 of COMBINER CHANNELS 1 and 2 is given as a typical example. The B path of channel 1 and the A and B paths of channel 2 of the combiner are similarly lined up.

*a.* Set the controls of COMBINER CHANNELS 1 and 2 (figs. 55 and 56) as follows:

(1) Place both IDLE-NORMAL switches in the IDLE position.

(2) Place the DIVERSITY switch in the 2-CHANNEL LOOPS 1 and 2 position.

(3) Place both LOOP CURRENT switches in the 60 MA position.

(4) Place both DISCRIMINATOR switches in the NORMAL position.

*b.* Line up the combiner as follows:

(1) Set the MARK-SPACE-DOT switch on the TRANSMITTER METER PANEL (fig. 66) to the MARK position.

(2) Connect Multimeter TS–352/U, set to the 50-volt dc scale, to the DISCRIMINATOR OUTPUT pin jacks (fig. 56) for channel 1 of the combiner.

(3) Energize the A path of channel 1 of the combiner by turning the ODD NUMBERED CHANNEL RECEIVER A OUTPUT switch (fig. 70) on the DIVERSITY ALIGNMENT PANEL to the ON position. Be sure that other OUTPUT switches are in the OFF position and the COMMON ATTENUATOR switch is in the 0 position.

(4) Adjust the LEVEL ADJUST A and BIAS ADJUST A controls of combiner channel 1 to obtain readings of 23 volts ±1 volt on the multimeter for both the MARK and SPACE positions of the MARK-SPACE-DOT switch (fig. 66). Use the DISCRIMINATOR switch (fig. 56) to maintain an up-scale reading on

the multimeter. Disconnect the multimeter.

(5) Set the DISCRIMINATOR switch to the NORMAL position and the MARK-SPACE-DOT switch to the MARK position.

(6) Connect the INPUT jack of the LOOP CURRENT METER on the RECEIVER METER PANEL (fig. 68) to the LOOP 1 MONITOR jack of the combiner. Adjust the CHANNEL 1 LOOP CURRENT ADJUST control until the LOOP CURRENT METER reads exactly 60 ma. Set the CHANNEL 1 IDLE-NORMAL switch to the NORMAL position and be sure the LOOP CURRENT METER reading does not change.

(7) Set the MARK-SPACE-DOT switch to the DOT position and depress the BIAS switch of the LOOP CURRENT METER on the RECEIVER METER PANEL. The control range of the BIAS ADJUST A control (fig. 56) in combiner channel 1 should permit the LOOP CURRENT METER bias reading to be varied over a minimum range from 55 to 65 ma. If this is the case, set the reading to exactly 60 ma. If not, retune the discriminator as outlined in (8) or (9) below.

(8) If a bias reading of 55 ma cannot be obtained with the BIAS ADJUST A control, the tuning capacity on the spacing side of the A path discriminator must be reduced. Do this by strapping the A TRIMMER capacitors on terminals 1 through 4 (fig. 220) of discriminator Z1. Proceed as follows:

(*a*) Set the BIAS ADJUST A control to the center of its travel.

(*b*) Remove the strapping between terminal 9 and terminals 1 through 4 of the A TRIMMER. Restrap terminal 9 to terminals 1 through 4 (singly or in combination) to obtain a bias reading on the LOOP CURRENT METER closest to 60 ma. The table below indicates the approximate bias change produced by the individual trimmer capacitors.

*Note.* Adding straps produce marking bias of the indicated amount. Removing strap produces spacing bias of the indicated amount. If bias to be corrected exceeds 5 ma, refer to paragraph 308 for corrective measures.

| Strapping connections for spacing frequency adjustment | |
|---|---|
| Strap trimmer A terminals | Approximate bias change (ma) |
| 9 to 4 | 2 |
| 9 to 3 | 4 |
| 9 to 2 | 8 |
| 9 to 1 | 16 |

(*c*) Repeat the instructions in (7) above to insure that the discriminator tuning is still within the required limits.

(9) If a bias reading of 65 ma cannot be obtained as instructed in (7) above with the BIAS ADJUST A control, the tuning capacity on the marking side of A path discriminator must be increased. Do this by strapping the A TRIMMER capacitors on terminals 5 through 8 of discriminator Z1. Proceed as follows:

(*a*) Set the BIAS ADJUST A control to the center of its travel.

(*b*) Remove the strapping between terminal 9 and terminals 5 through 8 of the A trimmer. Restrap terminal 9 to terminals 5 through 8 (singly or in combination) to obtain a bias reading on the LOOP CURRENT METER closest to 60 ma. The table below indicates the approximate bias change produced by the individual trimmer capacitors.

| Strapping connections for marking frequency adjustment | |
|---|---|
| Strap trimmer A terminals | Approximate bias change (ma) |
| 9 to 8 | 2 |
| 9 to 7 | 4 |
| 9 to 6 | 8 |
| 9 to 5 | 16 |

*Note.* Adding straps produce marking bias of the indicated amount. Removing strap produces spacing bias of the indicated amount. If bias to be corrected exceeds 5 ma refer to paragraph 308 for corrective measures to be taken.

(*c*) Repeat the instructions in (7) above to insure that the discriminator tuning is within the required limits.

(10) Repeat the procedures in (1) through (9) above to line up the B path of channel 1 and the A and B paths of channel 2 of the combiner. Use the appropriate jacks and controls for the particular channel path being lined up.

## 101. Line-up Check for Delay Amplifiers

The following procedure permits the tuning of the delay amplifiers of RECEIVER CHANNEL 1 and RECEIVER CHANNEL 2 to be checked and, if necessary, readjusted. The test setup described in paragraph 99*a*(1) through (9) is left intact. The procedure for checking the delay amplifier of RECEIVER A in RECEIVER CHANNEL 1 is given as a typical example. The same procedure is used for checking the remaining delay amplifiers.

*a*. See that the controls of COMBINER CHANNELS 1 and 2 (figs. 55 and 56) are in the positions shown in the following table.

| Controls | Position |
|---|---|
| IDLE-NORMAL | NORMAL. |
| DIVERSITY | 2 CHANNEL LOOPS 1 & 2. |
| LOOP CURRENT | 60 MA. |
| DISCRIMINATOR | NORMAL. |

*b*. Connect the INPUT jack of the LOOP CURRENT METER (fig. 68) to the LOOP 1 MONITOR jack of the combiner.

*c*. Energize RECEIVER A of RECEIVER CHANNEL 1.

*d*. Depress and hold the BIAS switch (fig. 68) of the LOOP CURRENT METER and, if necessary, adjust the BIAS ADJUST A control (fig. 56) in combiner channel 1 for a bias reading of exactly 60 ma.

*e*. Turn the DELAY ADJ control (fig. 54) on the delay amplifier of RECEIVER A in RECEIVER CHANNEL 1 from 0 to 10. The reading on the LOOP CURRENT METER should not change more than $\pm 2$ ma. If this requirement is met, the tuning is correct. Reset the DELAY ADJ control to 0.

*f*. If the requirement in *e* above is not met, readjust the tuning of the delay amplifier by means of trimmer capacitors C21 through C24. Strap terminal 1 to terminal 3, 5, 7, or 9 on terminal board TB6 (either singly or in combination) to bring the LOOP CURRENT METER reading within the prescribed limits. When the readjustment is completed, reset the DELAY ADJ control to 0.

*g*. Repeat the procedure in *d*, *e*, and *f* above to check the delay amplifier of RECEIVER B in RECEIVER CHANNEL 1 and both delay amplifiers of RECEIVER CHANNEL 2. Use the proper jacks and controls for the particular delay amplifier being checked.

*h*. Set the IDLE-NORMAL switches of COMBINER CHANNELS 1 and 2 to the IDLE position.

## 102. Line-up Check for SUBGROUP DEMODULATOR

Perform a line-up check for SUBGROUP DEMODULATOR A and SUBGROUP DEMODULATOR B by applying the output signals from the telegraph transmitter group to both demodulators, and checking to see that the proper signal level appears in the RECEIVER A and RECEIVER B LINE jacks of each receiver channel.

*a*. Arrange the test setup as follows:

(1) Set all IDLE-NORMAL switches (fig. 44) of transmitter channels 1 through 16 to the NORMAL position.

(2) Connect the OUTPUT EQUIP jacks of the LEVEL CONTROL & PLATE SUPPLY (fig. 49) to the IN jacks of the BRANCHING NETWORK on the DIVERSITY ALIGNMENT PANEL (fig. 70).

(3) Select one of the available audio frequency amplifiers in cabinet 3 and set both equalizer switches (fig. 61) to the EQUAL OUT position and both LEVEL ADJUST controls to 0.

(4) Connect the OUT 1 and OUT 2 jacks of the BRANCHING NETWORK to the INPUT EQUIP jacks of AMPLIFIER A and AMPLIFIER B, respectively, of the audio-frequency amplifier. Connect the OUTPUT EQUIP jacks of AMPLIFIER A and AMPLIFIER B to the INPUT EQUIP jacks of SUBGROUP DEMODULATOR A and SUBGROUP DEMODULATOR B, respectively.

*b.* Make the following measurements and adjustments:

(1) Connect the BRIDGING jacks of the LEVEL METER on the RECEIVER METER PANEL (fig. 68) to the MONITOR jacks of SUBGROUP DEMODULATOR A (fig. 51) and adjust the LEVEL ADJUST control of AMPLIFIER A of the audio-frequency amplifier for a meter reading of +12 dbm.

(2) Connect the BRIDGING jacks of the LEVEL METER to the MONITOR jacks of SUBGROUP DEMODULATOR B and adjust the LEVEL ADJUST control of AMPLIFIER B for a meter reading of +12 dbm.

(3) Successively connect the BRIDGING jacks of the LEVEL METER to the RECEIVER A and RECEIVER B LINE jacks (fig. 53) in each receiver channel and see that the meter reading is −14 dbm ±3 db.

*c.* Upon completion of the above check, the telegraph receiver group is ready for the final line-up procedure, which is performed as part of the system line-up procedure given in paragraphs 114 through 122.

## 103. Line-up Check for DELAY ADJUST METER

In the initial adjustments and tests of the RECEIVER METER PANEL (par. 99), the test for the DELAY ADJUST METER (fig. 68) was deferred. This was done because a properly aligned transmitter and corresponding combiner and associated receiver are required to test the DELAY ADJUST METER. Channels 7 and 8 of the AN/FGC–29 terminal are used for this purpose.

*a.* Arrange the test setup as follows:

(1) Furnish signals from TRANSMITTER CHANNELS 7 and 8 to RECEIVER CHANNEL 7, RECEIVER CHANNEL 8, and COMBINER CHANNELS 7 and 8 by way of the DIVERSITY ALIGNMENT PANEL (par. 99*a*(1)–(9)).

(2) Set both RECEIVER A OUTPUT switches on the DIVERSITY ALIGNMENT PANEL to the ON position and both RECEIVER B OUTPUT switches to the OFF position (fig. 70).

(3) Set the COMBINER CHANNELS 1 and 2 DIVERSITY switch (fig. 55) to the 2 CHANNEL LOOPS 7 and 8 position. Set both IDLE-NORMAL switches in the IDLE position (fig. 55) and both LOOP CURRENT switches to the 20 MA position (fig. 56).

(4) Set the DELAY-BALANCE switch of the DELAY ADJUST METER to the BALANCE position and the LOOP CURRENT switch to the ODD CHANNEL position (fig. 68).

(5) Connect the LOOP 7 EQUIP jack of the combiner to the ODD CHANNEL jacks of the DELAY ADJUST METER and the LOOP 8 EQUIP jack to the EVEN CHANNEL jack.

*b.* Perform the following measurements on the DELAY ADJUST METER:

(1) Adjust the combiner CHANNEL 7 LOOP CURRENT ADJUST control (fig. 55) to read exactly 20 ma on the LOOP CURRENT METER (use the 30 ma scale).

(2) Set the LOOP CURRENT switch of the DELAY ADJUST METER to the EVEN CHANNEL position and adjust the CHANNEL 8 LOOP CURRENT ADJUST control of the combiner to read exactly 20 ma on the LOOP CURRENT METER. The DELAY ADJUST METER should now read 0 ±2 ua. Meter deflections to the right are considered positive, and to the left, negative.

(3) Depress the BALANCE SENSITIVITY switch (fig. 68) and adjust the CHANNEL 8 LOOP CURRENT ADJUST control of the combiner to read +40 ua on the DELAY ADJUST METER. The meter should read +4 ua ±1 ua when the BALANCE SENSITIVITY switch is released.

(4) Depress the BALANCE SENSITIVITY switch and adjust the CHANNEL 8 LOOP CURRENT ADJUST control of the combiner to obtain a reading of 0 on the DELAY ADJUST METER.

(5) Release the BALANCE SENSITIVITY switch and set the DELAY-BALANCE switch to the DELAY position. Set the IDLE-NORMAL switches of COMBINER CHANNELS 7 and 8 to the NORMAL position. The DELAY ADJUST METER should read 0 ±4 ua.

(6) Set the RECEIVER A DELAY ADJ control of channel 7 to the maximum clockwise position. The DELAY ADJUST METER should read +20 ua ±5 ua.

(7) Set the RECEIVER A DELAY ADJ control in channel 8 to the maximum clockwise position. The DELAY ADJUST METER should read 0 ±4 ma.

(8) Return the RECEIVER A DELAY ADJ control in channel 7 to 0. The DELAY ADJUST METER should read −20 ua ±5 ua.

(9) Return the RECEIVER A DELAY ADJ control in channel 8 to 0. The DELAY ADJUST METER should read 0 ±4 ua.

*Note.* The readings given in (5) through (9) above are for a dotter speed of 30 cps (primary power frequency of 60 cps.) For a dotter speed of cps (primary power frequency of 50 cps), the correct readings will be reduced approximately 15 per cent.

## 104. Line-Up of Multiplexers TD–97/FGT–2

*a.* The multiplexers are not ready for traffic operation until they have been lined up by setting their OUTPUT LEVEL ADJUST controls (fig. 58) to provide the proper output levels. The line-up procedure adjusts the overall net gain of the multiplexers to zero. Normally, the adjustments can be made accurately by setting the OUTPUT LEVEL ADJUST controls in position 26.

*b.* When making an initial line-up of new or reconditioned equipment, the operation of each multiplexer should be checked. Signal Generator SG–15/PCM and the LEVEL METER of the TRANSMITTER METER PANEL, can be used to check the operation of the multiplexer and verify the accuracy of the line-up. Proceed as follows:

(1) Connect the OUTPUT EQUIP jacks of the multiplexer (fig. 58) to the TERMINATING jacks of the LEVEL METER (fig. 66).

(2) Insert an open twin plug in the TRANSLATED PATH INPUT EQUIP jacks and connect the OUTPUT jacks of the signal generator to the DIRECT PATH INPUT EQUIP jacks of the multiplexer.

(3) Adjust the output level of the signal generator to 0 dbm and the frequency to 2,000 cps.

(4) Set the OUTPUT LEVEL ADJUST control of the multiplexer to obtain a LEVEL METER reading of 0 dbm ±1 dbm.

(5) Insert the open twin plug in the DIRECT PATH INPUT EQUIP jacks and connect the OUTPUT jacks of the signal generator to the TRANSLATED PATH INPUT EQUIP jacks of the multiplexer leaving the signal level at 0 dbm and its frequency at 2,000 cps. The LEVEL METER should read 0 dbm ±1 db.

(6) If necessary, change the setting of the OUTPUT LEVEL ADJUST control to make the average of the readings obtained in (4) and (5) above as close as possible to 0 dbm. The final setting of the control should be within one point (1 db) of position 26.

## 105. Line-Up of Demultiplexers TD–98/FGR–3

*a.* The demultiplexers are not ready for traffic operation until they have been lined up by setting the LEVEL ADJUST controls (fig. 63) to provide the proper output levels. The line-up procedure adjusts the demultiplexers to provide an overall net gain of 15 db for telegraph service, 10 db for telephone service, or 5 db for facsimile service. Normally, the adjustments can be made accurately by setting the LEVEL ADJUST controls in the positions indicated in the following table.

| Service | Gain (db) | INPUT LEVEL ADJUST control setting | OUTPUT LEVEL ADJUST control setting |
|---|---|---|---|
| Telegraph | 15 | 50 | 41 |
| Telephone | 10 | 50 | 36 |
| Facsimile | 5 | 50 | 31 |

*b.* When making an initial line-up of new or reconditioned equipment, the operation of each demultiplexer should be checked. Signal Generator SG–15/PCM and the LEVEL METER on the RECEIVER METER PANEL (fig. 68) can be used to check the operation of the demultiplexer and verify the accuracy of the line-up.

*c.* To check the line-up for the direct path of the demultiplexer, proceed as follows:

(1) Connect the DIRECT PATH OUTPUT EQUIP jacks of the demultiplexer to the TERMINATING jacks of the LEVEL METER.

(2) Connect the OUTPUT jacks of the signal generator to the INPUT EQUIP jacks of the demultiplexer.

(3) Set the INPUT LEVEL ADJUST control of the demultiplexer in position 50.

(4) Adjust the output level of the signal generator to −5 dbm and its frequency to 2,000 cps.

(5) Adjust the DIRECT PATH OUTPUT LEVEL ADJUST control as indicated in (*a*), (*b*), or (*c*) below, depending upon the type of service for which the direct path of the demultiplexer is being lined up.

(*a*) *For telegraph service,* set the DIRECT PATH OUTPUT LEVEL ADJUST control of the demultiplexer to obtain a LEVEL METER reading of +10 dbm ±1 db. The setting should be within one point (1 db) of position 41.

(*b*) *For telephone service,* set the DIRECT PATH OUTPUT LEVEL ADJUST control of the demultiplexer to obtain a LEVEL METER reading of +5 dbm±1 db. The setting should be within one point (1 db) of position 36.

(*c*) *For facsimile service,* set the DIRECT PATH OUTPUT LEVEL ADJUST control of the demultiplexer to obtain a LEVEL METER reading of 0 dbm ±1 db. The setting should be within one point (1 db) of position 31.

*d.* To check the line-up for the translated path of the demultiplexer, proceed as follows:

(1) Connect the TRANSLATED PATH OUTPUT EQUIP jacks of the demultiplexer to the TERMINATING jacks of the LEVEL METER.

(2) Connect the OUTPUT jacks of the signal generator to the INPUT EQUIP jacks of the demultiplexer.

(3) Set the INPUT LEVEL ADJUST control of the demultiplexer in position 50.

(4) Adjust the output level of the signal generator to −5 dbm and its frequency to 4,300 cps.

(5) Adjust the TRANSLATED PATH OUTPUT LEVEL ADJUST control as indicated in (*a*), (*b*), or (*c*) below, depending upon the type of service for which the translated path of the demultiplexer is being lined up.

(*a*) *For telegraph service,* set the TRANSLATED PATH OUTPUT LEVEL ADJUST control of the demultiplexer to obtain a LEVEL METER reading of +10 dbm ±1 db. The setting should be within one point (1 db) of position 41.

(*b*) *For telephone service,* set the TRANSLATED PATH OUTPUT LEVEL ADJUST control of the demultiplexer to obtain a LEVEL METER reading of +5 dbm ±1 db. The setting should be within one point (1 db) of position 36.

(*c*) *For facsimile service,* set the TRANSLATED PATH OUTPUT LEVEL ADJUST control of the demultiplexer to obtain a LEVEL METER reading of 0 dbm ± 1 db. The setting should be within one point (1 db) of position 31.

## 106. Line-Up of Audio Frequency Amplifier AM–911/FG

The audio-frequency amplifiers are not ready for traffic operation until they have been lined up by setting the equalizer controls (fig. 61) and LEVEL ADJUST controls on AMPLIFIER A and AMPLIFIER B to provide the proper gain and frequency characteristics.

*a. General.* AMPLIFIER A and AMPLIFIER B are lined up separately, and not necessarily for the same type of circuit. The line-up at the AN/FGC–29 terminal is accomplished using Signal Generator SG–15/PCM and the LEVEL METER on the TRANSMITTER METER PANEL (fig. 66) or RECEIVER METER PANEL (fig. 68). To equalize a line circuit, the signal generator is located at the distant end of the circuit. Before lining up the amplifier, see that the strapping on terminal board TB3 is properly connected to match the circuit impedance (par. 53).

*b. Nonloaded Cable.*

(1) Set the equalizer switch of the amplifier in the NONLOADED CABLE position.

(2) Connect the OUTPUT EQUIP jacks of the amplifier to the TERMINATING jacks of the LEVEL METER.

(3) At the distant end of the circuit, connect the OUTPUT of Signal Generator SG–15/PCM to the 600-ohm winding of the line-matching transformer normally used with the cable circuit.

(4) Adjust the output level of the signal generator to 0 dbm and its frequency to 300 cps.

(5) Rotate the NONLOADED control of the amplifier to the extreme clockwise position. To reach this control, remove the screws that hold the front-panel cover in place.

(6) Adjust the LEVEL ADJUST control of the amplifier to obtain a reading of 0 dbm on the LEVEL METER.

(7) Adjust the output level of the signal generator to 0 dbm and its frequency to 6,000 cps.

(8) As a trial adjustment of the equalization, rotate the NONLOADED control of the amplifier counterclockwise to obtain a reading of approximately +5 dbm on the LEVEL METER.

(9) Adjust the output level of the signal generator to 0 dbm and its frequency to 300 cps.

(10) Adjust the LEVEL ADJUST control of the amplifier to obtain a reading of 0 dbm on the LEVEL METER.

(11) Adjust the output level of the signal generator to 0 dbm and its frequency to 6,000 cps.

(12) Adjust the NONLOADED control of the amplifier to obtain a reading of 0 dbm on the LEVEL METER.

(13) Repeat the steps in (9) through (12) above until the meter readings at 300 cps and at 6,000 cps are approximately equal and within 1/2 db of 0 dbm.

(14) When the instructions in (13) above have been completed, make a series of LEVEL METER measurements; keep the output level of the signal generator at 0 dbm and adjust its frequency successively to 300, 1,000, 2,000, 3,000, 5,000, and 6,000 cps. Record the results obtained.

(15) For a satisfactory line-up, the reading obtained in (14) above should not differ by more than 2 db. If necessary, make further adjustments of the LEVEL ADJUST and NONLOADED controls of the amplifier to obtain the flattest frequency characteristic possible.

(16) Replace the front-panel cover over the equalizer controls. Do not remove this cover or disturb the equalizer of LEVEL ADJUST control settings unless the line up procedure is being performed.

*c. Loaded Cable.*

(1) Set the equalizer switch of the amplifier in the LOADED CABLE position.

(2) Connect the OUTPUT EQUIP jacks of the amplifier to the TERMINATING jacks of the LEVEL METER.

(3) At the distant end of the circuit, connect the OUTPUT of Signal Generator SG–15/PCM to the 600-ohm winding of the line-matching transformer normally used with the cable pair.

(4) Adjust the output level of the signal generator to 0 dbm and its frequency to 1,500 cps.

(5) Adjust the LEVEL ADJUST control of the amplifier to obtain a reading of 0 dbm on the LEVEL METER.

(6) Adjust the output level of the signal generator to 0 dbm and its frequency to 300 cps.

(7) Adjust the LOADED LOW control of the amplifier to obtain a reading of 0 dbm on the LEVEL METER. To reach to the equalizer controls, remove the two screws that hold the front-panel cover in place and take off the cover.

(8) Adjust the output level of the signal generator to 0 dbm and its frequency to 3,500 cps.

(9) Adjust the LOADED HIGH control of the amplifier to obtain a reading of 0 dbm on the LEVEL METER.

(10) Make a series of LEVEL METER measurements; keep the output level of the signal generator at 0 dbm and adjust its frequency successively to 300, 1,000, 2,000, 3,000 and 3,500 cps. Record the results obtained.

(11) For a satisfactory line-up, the readings obtained in (10) should not differ by more than 2 db. If necessary, make further adjustments of the LEVEL ADJUST and the LOADED LOW and HIGH controls of the amplifier to obtain the flattest frequency characteristic possible.

(12) Replace the front-panel cover over the equalizer controls. Do not remove this cover or disturb the equalizer or LEVEL ADJUST control settings unless a com-

plete line-up of the audio-frequency amplifier is being performed.

*d. Flat Gain.*

(1) Set the equalizer switch of the amplifier in the EQUAL OUT position.

(2) Adjust the LEVEL ADJUST control of the amplifier to obtain the desired gain. The gain of the amplifier may be read directly on the scale marking of the LEVEL ADJUST control when the equalizer switch is set in the EQUAL OUT position. For example: To obtain a gain of 25 db, set the LEVEL ADJUST control to position 25.

## Section IV. SYSTEM LINE-UP PROCEDURE

### 107. General

Before starting traffic operation over the AN/FGC–29 terminal, perform a system line up to insure that the operating levels are correct throughout the system. The system line-up procedure consists of a series of level measurements made at important test points in the system, accompanied by level adjustments to set each level to its proper value. Figures 248 and 249 show all test points and controls in the AN/FGC–29 terminal. After the AN/FGC–29 terminal has been lined up in accordance with the instructions in paragraphs 108 through 110, the final adjustment of delay and level in the individual receivers can be made (par. 111). The line-up of the multiplexers, demultiplexers, and audio-frequency amplifiers should be approximately correct. Do not alter the setting of any front panel LEVEL ADJUST controls by more than two points (2 db) during the system line-up without investigating the reason for the change. If a greater readjustment appears necessary at any point in the system, check the equipment line-up and be sure that each equipment unit is functioning properly. Upon completion of the system line-up, make a record of the normal setting of each LEVEL ADJUST and DELAY ADJ control and the normal level measured at each test point in the system. Keep this record available as an aid in future troubleshooting.

### 108. Line-Up in Transmitting Direction

The system line-up procedure for the transmitting direction consists of the measurement and adjustment of operating levels at significant points in the transmitting portion of the system. Level measurements at the AN/FGC–29 terminal can be made with the LEVEL METER. When making bridging measurements at MONITOR jacks, use the BRIDGING jacks of the LEVEL METER. For terminating measurements at LINE or EQUIP jacks, use the TERMINATING jacks except where otherwise indicated. Measure and adjust operating levels through this part of the system, beginning at the output of the telegraph transmitting group and the telephone or facsimile equipment and ending at the input of the radio transmitter (*a* through *e* below).

*a. Terminal Equipment Output.* The first step in system line-up procedure is to adjust the output level of the telegraph, telephone, or facsimile terminal equipment to correct values.

(1) *Telegraph transmitter group.* The operating levels for telegraph operation in either space or frequency diversity are described in *a* and *b* below.

(*a*) *Space diversity.* The correct power level per telegraph channel is —10 dbm. The corresponding multichannel level for 16 channels, as measured at the JACK GROUP 1 EQUIP. OUT MONITOR jacks on the 3-KC SEND BAND TEST PANEL, is +2 dbm, obtained by adjusting the LEVEL ADJUST control in the LEVEL CONTROL & PLATE SUPPLY.

(*b*) *Frequency diversity.* When the carrier telegraph channels are operated in frequency diversity, the transmitting levels are set 6 db higher than for space diversity because the branching network in the multiplexer introduces a 6-db loss. The correct level per channel is —4 dbm. The corresponding multichannel level for 16 channels, as measured at the JACK GROUP 1 EQUIP. OUT or MONITOR jacks on the 3-KC SEND BAND TEST PANEL, is +8 dbm, obtained by adjusting the LEVEL ADJUST control on the LEVEL CONTROL & PLATE SUPPLY.

(2) *Telephone.* The normal telephone test tone is 1,000 cps signal at a level of 0 dbm

applied to the two-wire transmitting input to the hybrid coil arrangement. This results in a level of −4 dbm at the EQUIP. OUT or MONITOR jacks of the associated jack group on the 3KC SEND BAND TEST PANEL.

(3) *Facsimile.* The correct signal level at the output of the facsimile transmitter is 0 dbm and is measured at the EQUIP. OUT or MONITOR jacks of the associated jack group in the 3KC SEND BAND TEST PANEL.

*b. Multiplexer Input.* The correct input levels for the transmission paths of the multiplexer are given in (1), (2), and (3) below. Check the input levels at the INPUT LINE or INPUT MONITOR jacks before adjusting the multiplexer output levels.

(1) *Telegraph.* The correct power level for the 16 carrier telegraph channels at the multiplexer input is +2 dbm, corresponding to −10 dbm per channel.

(2) *Telephone.* The correct level for a telephone test tone at the multiplexer input is −4 dbm.

(3) *Facsimile.* The correct level for a facsimile signal at the multiplexer input is 0 dbm.

*c. Multiplexer Output.* The correct output levels for the multiplexer are given in (1), (2), and (3) below. Measure the levels at the OUTPUT EQUIP. or OUTPUT MONITOR jacks; then readjust the OUTPUT LEVEL ADJUST control, if necessary, to obtain the correct levels.

(1) *Telegraph.* The correct power level for the 16 carrier telegraph channels at the multiplexer output is +2 dbm, corresponding to −10 dbm per channel. When the carrier telegraph signals are transmitted in frequency diversity through both paths of the same multiplexer, each input signal appears in the output as two different signal tones. In this case, the correct levels at the multiplexer output are +5 dbm for 16 channels (32 tones) and −7 dbm per channel (2 tones). These levels apply only to frequency diversity options A and F given in paragraph 56.

(2) *Telephone.* The correct level for a telephone test tone at the multiplexer output is −4 dbm.

(3) *Facsimile.* The correct level for facsimile signals at the multiplexer output is 0 dbm.

*d. Audio-Frequency Amplifier Input.* The levels at the input of the audio-frequency amplifier will vary widely, depending on the transmission loss in the associated line facility. The input levels can usually be measured at the INPUT LINE or INPUT MONITOR jacks, but the measurement is not essential for a system line-up.

*e. Audio-Frequency Amplifier Output.* The correct output levels for the audio-frequency amplifier are always the same as the signal levels transmitted by the equipment at the distant end of the line ((1) and (2) below). Measure the levels at the OUTPUT EQUIP or OUTPUT MONITOR jacks; then readjust the LEVEL ADJUST control, if necessary, to obtain the correct levels.

(1) *3-kc facilities.* When 3-kc line facilities are used in the transmitting portion of the system, the output levels of the associated audio-frequency amplifier should be the same as those at the output of the multiplexer (*c* above).

(2) *6-kc facilities.* When 6-kc facilities are used in the transmitting portion of the system, the output level of the associated audio-frequency amplifier should be the same as at the output of the terminal equipment (*a* above).

## 109. Line-Up of Radio Circuit

The radio circuit should be lined up so that there is a net loss of 5 db from the input of the radio transmitter to the output of the radio receiver.

*a. Radio Transmitter Input.* The correct input levels for the radio transmitter are given in (1), (2), and (3) below.

(1) *Telegraph.* The correct power level for 16 carrier telegraph channels at the radio transmitter input is +2 dbm, corresponding to −10 dbm per channel. When the carrier telegraph signals are transmitted by frequency diversity in accordance with frequency diversity option A or F (par. 56), the correct levels at the radio transmitter input are +5 dbm for 16 channels (32 tones) and −7 dbm per channel (2 tones).

(2) *Telephone.* The correct level for a telephone test tone at the radio transmitter input is −4 dbm.

(3) *Facsimile.* The correct level for facsimile signals at the radio transmitter input is 0 dbm.

*b. Radio Receiver Output.* The output of the radio receiver should be adjusted to the levels listed in (1), (2), and (3) below.

(1) *Telegraph.* The correct power level for 16 carrier telegraph channels at the radio receiver output is −3 dbm, corresponding to −15 dbm per channel. When the carrier telegraph signals are received by frequency diversity option A or F (par. 56), the correct levels are 0 dbm for 16 channels (32 tones), corresponding to −12 dbm per channel (2 tones).

(2) *Telephone.* The correct level for a telephone test tone at the radio receiver output is −9 dbm.

(3) *Facsimile.* The correct level at the radio receiver output for facsimile signals is −5 dbm.

## 110. Line-Up in Receiving Direction

The system line-up procedure for the receiving direction consists of the measurement and adjustment of operating levels at significant points in the receiving portion of the system. Measure and adjust operating levels through this part of the system, beginning at the output of the radio receiver and ending at the input to the telegraph receiver group or telephone or facsimile terminal equipment (*a* through *e* below). Fading is usually present on radio circuits and causes the received signal levels to vary. When measuring levels in the presence of fading, use the maximum reading of the LEVEL METER to indicate the level being measured. Under conditions of severe fading, it may be difficult, or even impossible, to measure levels accurately in the receiving portion of the system with signals derived from the radio receiver. Under such adverse fading conditions, use the signal substitution method of line-up described in *f* below.

*a. Radio Receiver Output.* The correct output levels for the radio receiver are given in (1), (2), and (3) below.

(1) *Telegraph.* The correct power level for 16 carrier telegraph channels at the radio receiver output is −3 dbm, corresponding to −15 dbm per channel. When the carrier telegraph signals are received in frequency diversity through one channel of the radio receiver, each telegraph signal is received as two different signal tones. In this case, the correct power levels are 0 dbm for 16 channels (32 tones), corresponding to −12 dbm per channel (2 tones). These levels apply only to frequency diversity options A and F (par. 56).

(2) *Telephone.* The correct level for a telephone test tone at the radio receiver output is −9 dbm.

(3) *Facsimile.* The correct level for facsimile signals at the radio receiver output is −5 dbm.

*b. Demultiplexer Input.* The correct levels for the demultiplexer are given in (1), (2), and (3) below. Check the input level at the INPUT LINE or INPUT MONITOR jacks before adjusting the demultiplexer output levels.

(1) *Telegraph.* The correct power level for 16 carrier telegraph channels at the demultiplexer input is −3 dbm, corresponding to −15 dbm per channel. When the carrier telegraph signals are received by frequency diversity in accordance with frequency diversity option A or F (par. 56), the correct power level is 0 dbm for 16 channels (32 tones), corresponding to −12 dbm per channel (2 tones).

(2) *Telephone.* The correct level for a telephone test tone at the demultiplexer input is −9 dbm.

(3) *Facsimile.* The correct level for facsimile signals at the demultiplexer input is −5 dbm.

*c. Demultiplexer Output.* The correct output levels for the transmission paths of the demultiplexer are given in (1), (2), and (3) below. Measure the levels at the OUTPUT EQUIP or OUTPUT MONITOR jacks of the demultiplexer; then readjust the OUTPUT LEVEL ADJUST controls, if necessary, to obtain the correct levels.

(1) *Telegraph.* The correct power level for 16 carrier telegraph channels at the demultiplexer output is +12 dbm, corresponding to 0 dbm per channel.

(2) *Telephone.* The correct level for a telephone test tone at the demultiplexer output is +1 dbm.

(3) *Facsimile.* The correct level for facsimile signals at the demultiplexer output is 0 dbm.

*d. Audio-Frequency Amplifier Input.* The levels at the input of the audio-frequency amplifier will vary widely, depending on the transmission loss in the associated line facility. The input levels can usually be measured at the INPUT LINE or INPUT MONITOR jacks, but the measurement is not essential for a system line-up.

*e. Audio-Frequency Amplifier Output.* The correct output levels for the audio-frequency amplifier are always the same as the signal levels transmitted by the equipment at the distant end of the line ((1) and (2) below). Measure the levels at the OUTPUT EQUIP or OUTPUT MONITOR jacks; then readjust the LEVEL ADJUST control, if necessary, to obtain the correct levels.

(1) *3-kc facilities.* When 3-kc line facilities are used in the receiving portion of the system, the output levels of the associated audio frequency amplifier should be the same as those at the output of the demultiplexer (*c* above).

(2) *6-kc facilities.* When 6-kc facilities are used in the receiving portion of the system, the output levels of the associated audio-frequency amplifier should be the same as those at the output of the radio receiver (*a* above).

*f. Line-Up by Signal Substitution Method.* Whenever selective fading on the radio circuit makes it impossible to obtain accurate level measurements in the receiving portion of the system, use the signal substitution method. Substitute a source of signals, such as Signal Generator SG–15/PCM, for the output of the radio receiver. Use test frequencies between 400 and 3,000 cps to represent signals intended for the direct path of the demultiplexers. Use test frequencies between 3,300 and 5,900 cps to represent signals intended for the translated path of the demultiplexer. Use test signal levels appropriate to each particular application (*a* above).

## 111. Telegraph Receiver Group, Delay Equalizing Adjustments

Delay equalizing adjustments of the receiver channels are made after the system line-up adjustments given in paragraphs 108 through 110 have been completed and all interconnecting facilities and associated equipment are operating normally. Variations in the equipment delay characteristics for the different diversity signal paths are compensated so that optimum diversity combining can be realized. The settings of the DELAY ADJ controls of all receiver channels should be determined and recorded, particularly when optional system arrangements are used that may alter the relative delay of diversity signals. For example, changing the system from operation in space diversity to operation in frequency diversity may require different settings of the DELAY ADJ controls for optimum performance. By determining and recording the control settings for the various operating conditions, the necessity for making a delay line-up each time the system is changed can be avoided. The following delay equalizing procedure is given for RECEIVER CHANNEL 1 and RECEIVER CHANNEL 2 as a typical example. The other receivers are similarly equalized in pairs together with their associated combiner. The delay equalizing adjustments require the transmission of test signals from the telegraph transmitter group at the distant end of the system over the radio circuit to the local telegraph receiver group. Delay adjustments can be made whenever radio transmission conditions are normal.

*a.* Before beginning the delay adjustments in the receiving terminal contact the remote transmitting terminal and have the distant operating personnel make the following circuit arrangements.

(1) Set the MARK-SPACE-DOT switch on the TRANSMITTER METER PANEL to the DOT position and connect the DOTTER OUTPUT jack to the LOOP 1 EQUIP jack of TRANSMITTER CHANNELS 1 and 2.

(2) In TRANSMITTER CHANNELS 1 and 2, set both LOOP CURRENT SELECTOR switches to the 60MA position, both LOOP TERMINATION switches to the NEG position, both IDLE-NORMAL switches to the NORMAL position, and the DIVERSITY switch to the 4 CHANNEL LOOP 1 ONLY position.

(3) Connect the INPUT jack of the LOOP CURRENT METER on the TRANSMITTER METER PANEL to the LOOP 1 MONITOR jack on the transmitter. Depress the BIAS switch and adjust the CHANNEL 1 LOOP CURRENT ADJUST control unit, the meter reads 60 ma $\pm$ 5 ma.

*b.* The relative delays of the four diversity signals of RECEIVER CHANNEL 1 and RECEIVER CHANNEL 2 of the local telegraph receiver group can now be equalized.

*c.* Proceed as follows to be sure the four diversity signals are being received at approximately the correct level and that they do not have excessive bias.

(1) Set the four DELAY ADJ controls (fig. 54) in RECEIVER CHANNEL 1 and RECEIVER CHANNEL 2 to their 0 positions.

(2) Connect the BRIDGING jacks of the LEVEL METER on the RECEIVER METER PANEL (fig. 69) successively to each of the MONITOR jack pairs of RECEIVER CHANNEL 1 and RECEIVER CHANNEL 2 (fig. 53). See that the meter reads −20 dbm ±3 db. Readjust the corresponding LEVEL ADJ control in the appropriate receiver if necessary to obtain the correct level.

*Note.* Selective fading in the radio path will cause the meter to vary widely. Use the peak reading of the meter as an indication of the received signal level.

(3) Set the DIVERSITY switch (fig. 55) on COMBINER CHANNELS 1 and 2 to the 2 CHANNEL LOOPS 1 and 2 position and both IDLE-NORMAL switches to the IDLE position.

(4) Set both DISCRIMINATOR switches of the combiner to the NORMAL position and both LOOP CURRENT switches to the 60 MA position (fig. 56).

(5) Connect the ODD CHANNEL jack of the DELAY ADJUST METER on the RECEIVER METER PANEL (fig. 68) to the LOOP 1 EQUIP jack of the combiner. See that the INPUT jack of the LOOP CURRENT METER is not in use and that the DELAY-BALANCE switch is in the BALANCE position.

(6) Connect the EVEN CHANNEL jack of the DELAY ADJUST METER (fig. 68) to the LOOP 2 EQUIP jack of the combiner.

(7) Set the LOOP CURRENT switch of the DELAY ADJUST METER to the ODD CHANNEL position and adjust the CHANNEL 1 LOOP CURRENT ADJUST control of the combiner for a reading of 60 ma on the LOOP CURRENT METER.

(8) Insert an open twin plug in the RECEIVER A LINE jacks of RECEIVER CHANNEL 1 to render the RECEIVER A inoperative, and set the IDLE-NORMAL switch of combiner channel 1 to the NORMAL position.

(9) Depress the BIAS switch of the LOOP CURRENT METER and see that the meter reads approximately 60 ma for the B path signal of combiner channel 1.

*Note.* While checking the bias on a single diversity signal in this manner, in the presence of selective fading, the meter reading will fluctuate whenever the signal fades excessively. Ignore these fluctuations when checking for bias.

(10) Remove the open twin plug from the RECEIVER A LINE jacks and insert in the RECEIVER B LINE jack of RECEIVER CHANNEL 1. Repeat the instructions in (9) above to check the bias of the A path signal of combiner channel 1.

(11) Similarly, check the bias of the A and B path signals of combiner channel 2 by repeating the steps on (7) through (10) above for RECEIVER CHANNEL 2 and combiner channel 2 with the LOOP CURRENT switch of the DELAY ADJUST METER set in the EVEN CHANNEL position.

*d.* Proceed as follows to determine which signal has the greatest delay and also to delay the other three signals as required to match the signal having the greatest delay.

(1) Insert open twin plugs into the RECEIVER B LINE jacks of RECEIVER CHANNEL 1 and RECEIVER CHANNEL 2 to render the B paths inoperative.

(2) Set both IDLE-NORMAL switches of COMBINER CHANNELS 1 and 2 in the IDLE position.

(3) With the DELAY-BALANCE switch of the DELAY ADJUST METER in the BALANCE position, depress the BALLANCE SENSITIVITY switch and adjust the CHANNEL 2 LOOP CURRENT ADJUST control of the combiner to obtain a 0 reading on the DELAY ADJUST METER. Release the DELAY-BALANCE switch.

(4) Set the IDLE-NORMAL switches to the NORMAL position and the DELAY-BALANCE switch to the DELAY position.

(5) Equalize the delay between the two A path signals by adding delay to the re-

ceiver indicated by the DELAY ADJUST METER. When the DELAY ADJUST METER deflects to the right, the even-numbered receiver requires additional delay. When the meter needle deflects to the left, the odd-numbered channel requires additional delay. Rotate the DELAY ADJ control of the indicated receiver clockwise until the DELAY ADJUST METER reads zero.

*Note.* The response of the DELAY ADJUST METER is heavily damped to cancel out the effect of selective fading. The correct setting of a DELAY ADJ control is indicated when the average meter reading is zero. Always add delay to the indicated receiver (clockwise rotation of the DELAY ADJ control) when equalizing. Do not obtain a zero meter reading by subtracting delay (counterclockwise rotation of the DELAY ADJ control) from the other receiver.

(6) Remove the open circuit plugs from the RECEIVER B LINE jacks and insert them into the RECEIVER A LINE jacks of both receivers. Repeat the procedure in (5) above for the two B path signals, adding delay to the indirated receiver with the appropriate DELAY ADJ control if required.

(7) Remove the open circuit plug from the RECEIVER A LINE jacks of RECEIVER CHANNEL 1 and insert it into the RECEIVER B LINE jacks of RECEIVER CHANNEL 1. Repeat the procedure in (5) above for the A path of RECEIVER CHANNEL 1 and the B path of RECEIVER CHANNEL 2, adding delay to the indicated receiver with the appropriate DELAY ADJ control, if required.

(8) Remove the open circuit plugs from the RECEIVER B LINE jacks of RECEIVER CHANNEL 1 and the RECEIVER A LINE jacks of RECEIVER CHANNEL 2. Insert them into the RECEIVER A LINE jacks of RECEIVER CHANNEL 1 and the RECEIVER B LINE jacks of RECEIVER CHANNEL 2. Repeat the procedure in (5) above for the B path of RECEIVER CHANNEL 1 and the A path of RECEIVER CHANNEL 2, adding delay to the indicated receiver with the appropriate DELAY ADJ control, if required.

(9) Record the settings of the four DELAY ADJ controls for the particular system arrangement for future reference.

(10) Remove the open circuit twin plugs and connect the BRIDGING jacks of the LEVEL METER, successively to each pair of MONITOR jacks on RECEIVER CHANNEL 1 and RECEIVER CHANNEL 2. If necessary, adjust the associated LEVEL ADJ control for a maximum meter reading of −20 dbm.

(11) Remove all plugs and restore the receivers and combiners to normal. Restore the transmitter at the distant transmitter site to normal.

*e.* RECEIVER CHANNEL 1 and RECEIVER CHANNEL 2 are now delay-equalized for the particular system arrangement. Delay-equalize the remaining receivers by following the procedures in *c* and *d* above with the appropriate controls for the particular receivers being equalized. At the completion of the delay equalizing procedure, the terminal is ready to handle traffic.

## 112. Routine Line-Up Checks

Perform routine line-up checks at regular intervals to determine whether or not circuit conditions are normal. Make routine checks of signal levels without interrupting service by connecting the BRIDGING jacks of the LEVEL METER (figs. 66 and 68) to any MONITOR jack pair and see that the signal level is normal. These jacks can also be used with Electrical Headset H–110/G (fig. 12) to make listening tests for normal signals and any abnormal condition, such as excessive noise or intermittent interruptions. Make routine checks of dc loop signals without interrupting service by connecting the LOOP CURRENT METER to the loop MONITOR jacks on transmitters and combiners. See that the marking loop currents are either 20 or 60 ma, as required, and that loop signals are normal. See that the OUTPUT VOLTAGE meters on the ac power switching panels (fig. 73) read 230 volts, indicating correct operation of the voltage regulators. Routine line-up checks are essential to the maintenance of good quality service with a high degree of continuity.

## 113. Level Measurements

The performance of line-up procedures on the AN/FGC–29 terminal requires measurement and adjustment of signal levels at various points in the equipment as shown in figures 248 and 249. The level measurements required for a system line-up can be made either on a terminating basis or on a bridging basis.

*a. Terminating Measurements.* To make a terminating measurement of signal levels in 600-ohm circuits, use the TERMINATING jacks of the LEVEL METER to terminate the circuit at the point of measurement. To make a terminating measurement in the LINE jacks of the receivers, use the BRIDGING jacks of the LEVEL METER. Terminating measurements interrupt the continuity of the circuit and cannot be made on a working circuit without interfering with traffic operation. Terminating measurements can be made with the LEVEL METER connected to the following jacks in the AN/FGC–29 terminal. For the measurements indicated, use the TERMINATING jacks of the LEVEL METER and measure signal level in dbm, except as otherwise noted.

| Component | Measure input at jacks | Measure output at jacks |
|---|---|---|
| Multiplexer | INPUT LINE | OUTPUT EQUIP. |
| Demultiplexer | INPUT LINE | OUTPUT EQUIP. |
| Audio-frequency amplifier. | INPUT LINE | OUTPUT EQUIP. |
| LEVEL CONTROL & PLATE SUPPLY. | INPUT LINE | OUTPUT EQUIP. |
| SUBGROUP MODULATOR. | INPUT BUS | OUTPUT EQUIP. |
| SUBGROUP DEMODULATOR. | INPUT LINE | None. |
| Transmitter | None | CHANNEL OUTPUT. |
| Receiver | LINE* | None. |
| 3KC SEND BAND TEST PANEL. | EQUIP. OUT | None. |
| 3KC RECEIVE BAND TEST PANEL. | LINE OUT | None. |

*Measurement in these jacks is made with BRIDGING jacks of LEVEL METER. Meter reading does not indicate signal level in dbm.

*b. Bridging Measurements.* To make a bridging measurement, use the BRIDGING jacks of the LEVEL METER bridged across the circuit at the point of measurement. Bridging measurements can be made without interrupting the circuit or interfering with traffic operation. Bridging measurements can be made with the BRIDGING jacks of the LEVEL METER connected to the following jacks in the AN/FGC–29 terminal. The measurements indicate signal level in dbm except as otherwise noted.

| Component | Measure input at jacks | Measure output at jacks |
|---|---|---|
| Multiplexer | INPUT MONITOR. | OUTPUT MONITOR. |
| Demultiplexer | INPUT MONITOR. | OUTPUT MONITOR. |
| Audio frequency amplifier. | INPUT MONITOR. | OUTPUT MONITOR. |
| LEVEL CONTROL & PLATE SUPPLY. | INPUT MONITOR. | OUTPUT MONITOR. |
| SUBGROUP MODULATOR. | INPUT MONITOR. | OUTPUT MONITOR. |
| SUBGROUP DEMODULATOR. | INPUT MONITOR. | None. |
| Transmitter | None | CARRIER MONITOR.* |
| Receiver | MONITOR* | METER.* |
| 3KC SEND BAND TEST PANEL. | None | MONITOR. |
| 3KC RECEIVE BAND TEST PANEL. | None | MONITOR. |

*Meter reading does not indicate signal level in dbm. Meter measures an internal signal, which is proportional to input or output signal.

# Section V. OPERATING PROCEDURE

## 114. General

Routine handling of telegraph, telephone, or facsimile traffic may require certain switching, patching, monitoring, and level adjustment operations to be performed. During periods of severe selective fading on the radio circuit, it may be necessary to operate the telegraph transmitter or receiver groups in four-channel diversity. For efficient operation of the communication system, the operating personnel at the communication

center must have means for voice or teletypewriter communication to the radio transmitter and receiver sites and also to the AN/FGC–29 terminal at the other end of the radio circuit.

## 115. Operating Procedure, Telegraph Transmitter Group

*a. Operation of Transmitting Loops.* Arrange the transmitters for operation with the polarity of battery or ground termination supplied by the external loop equipment and for the required loop current as follows:

(1) For transmitting loops energized by —130 volt external battery, set the LOOP TERMINATION switch (fig. 45) of the associated transmitter channel to the NEG position.

(2) For transmitting loops energized by +130 volt external battery set the LOOP TERMINATION switch of the associated transmitter channel to the POS position.

(3) For transmitting loops not provided with external battery, set the LOOP TERMINATION switch of the associated transmitter to the GRD position. In this switch position the transmitter channel supplies a potential of —130 volts to ground to the external loop.

(4) For a transmitting loop that requires a 20-ma operating current, set the LOOP CURRENT SELECTOR switch (fig. 45) of the associated transmitter to the 20MA position. For a loop that requires a 60-ma current, set the switch to the 60MA position. Set the loop current to the required 20-ma or 60-ma value as follows.

(*a*) Place the external loop in the closed (marking) condition.

(*b*) Select the proper sensitivity for the LOOP CURRENT METER on the TRANSMITTER METER PANEL by operating the MILLIAMPERES switch (fig. 66) to the appropriate position (30 position for 20 ma loops and 90 position for 60 ma loops.)

(*c*) Connect the INPUT jack (fig. 66) of the LOOP CURRENT METER to the loop MONITOR jack (fig. 44) of the associated transmitter channel and set the loop current to 20 ma or 60 ma with the appropriate LOOP CURRENT ADJUST control.

*b. Diversity Operation of Telegraph Transmitter Group.* The AN/FGC–29 terminal normally operates in two-channel diversity (par. 38*a*(1)) to provide 16 teletypewriter circuits. To maintain communication under fading or noise conditions where two-channel diversity is unsatisfactory, four-channel diversity operation (par. 38*a*(2)) can be used. Any or all of TRANSMITTER CHANNELS 15 and 16 can be operated in four-channel diversity. When operating in 4-channel diversity, service on the even-numbered loop circuit is interrupted to maintain service on the odd-numbered loop circuit. For this reason, high priority circuits should be assigned to odd-numbered loops. When all transmitters are operated in 4-channel diversity, only eight teletypewriter circuits are available for use in the transmitting direction.

(1) *Two-channel to 4-channel.*

(*a*) Operate the DIVERSITY switch on the transmitter involved to the 4 CHANNEL LOOP 1 only position. This switch may be operated either manually at the equipment or electrically from a remote control station.

(*b*) Make sure that both LOOP CURRENT SELECTOR switches and both LOOP TERMINATION switches of the transmitter are set to the same positions.

(*c*) See that the corresponding combiner at the distant terminal is arranged for four-channel diversity operation.

(2) *Four-channel to two-channel.*

(*a*) Make sure that the LOOP CURRENT SELECTOR and LOOP TERMINATION switches of the transmitter are set to meet the battery and current requirements of the corresponding loop circuits.

(*b*) Operate the DIVERSITY switch on the transmitter involved to the 2 CHANNEL loops 1 and 2 position.

(*c*) See that the corresponding combiner at the distant terminal is arranged for two-channel diversity operation.

*Note.* The responsibility for authorizing the use of four-channel diversity should normally rest with the receiving terminal.

*c. Use of Controls.* After the telegraph transmitter group has been lined up (par. 96) and the transmitting loops properly adjusted (*a* above),

only the DIVERSITY switches of the transmitters (*b* above) are required during normal operation. Do not disturb the controls of the SUBGROUP MODULATOR and LEVEL CONTROL & PLATE SUPPLY.

*d. Use of Jacks.* In the telegraph transmitting group are single jacks that are used with cords equipped with single plugs, which are associated with dc telegraph circuits, and twin jacks that are used with cords equipped with twin plugs, which are associated with carrier telegraph circuits.

(1) On the front panel of each transmitter are two groups of jacks associated with the telegraph transmitting loops. In each group is a LOOP jack, an EQUIP jack, and a MONITOR jack. Use the LOOP and EQUIP jacks and patching cords equipped with single plugs for making changes in telegraph circuit routing. The LOOP jack allows a connection to be made to the associated loop and permits it to be patched to a different EQUIP jack. The EQUIP jack allows a connection to be made to the input circuit of the associated transmitter and permits it to be patched to a different LOOP jack. Whenever a patch is made, check the transmitting loop for proper operation (*a* above). Connections to the LOOP or EQUIP jacks cannot be made without interrupting the telegraph circuit. The MONITOR jack is in series with the output of the jack group. It permits the LOOP CURRENT METER to be connected in series with the input circuit of the transmitter without interrupting its continuity.

(2) On the front panel of each transmitter are two pairs of CHANNEL OUTPUT jacks and two pairs of CARRIER MONITOR jacks, used with cords equipped with twin plugs. The CHANNEL OUTPUT jacks remove the transmitter from the associated bus and permit the TERMINATING jacks of the LEVEL METER to be connected to the output of the transmitter for level measurement. The CHANNEL OUTPUT jacks cannot be used without interrupting the telegraph circuit. The CARRIER MONITOR jacks permit the BRIDGING jacks of the LEVEL METER to be connected to internal test points (fig. 45) in the associated transmitter without interrupting the circuit to see that the proper signal level is being transmitted. These CARRIER MONITOR jacks may also be used with Electrical Headset H–110/G to see that frequency-shift signals are being transmitted.

(3) On the front panel of the SUBGROUP MODULATOR are two groups of INPUT jacks and one group of OUTPUT jacks. In each group of INPUT jacks are a pair of BUS jacks, a pair of EQUIP jacks, and a pair of MONITOR jacks. The INPUT BUS jacks permit connection to be made to the odd or even channel busses. The INPUT EQUIP jacks permit connection to be made to the DIRECT PATH or TRANSLATED PATH input circuits of the SUBGROUP MODULATOR. In the OUTPUT jack group are a pair of EQUIP jacks, a pair of LINE jacks, and a pair of MONITOR jacks. The OUTPUT EQUIP jacks permit connection to be made to the output circuit of the SUBGROUP MODULATOR. The OUTPUT LINE jacks permit connection to be made to the input circuits of the equipment which follows. The BUS, EQUIP, and LINE jacks cannot be used without interrupting the circuit and are used only when the terminal is out of service. The MONITOR jacks are bridged across the output side of each jack group with respect to the signal path. They permit the BRIDGING jacks of the LEVEL METER to be connected to the circuit without interrupting its continuity.

(4) On the front panel of the LEVEL CONTROL PLATE SUPPLY are two groups of jack pairs associated with the amplifier in use. The LINE and EQUIP jacks cannot be used without interrupting the circuit and are used only when the telegraph transmitter group is out of service. The INPUT MONITOR and OUTPUT MONITOR jacks are bridged across the circuit at the output of the jack groups with respect to the signal path. They permit the BRIDGING jack of the LEVEL METER to be

connected to the circuit without interrupting its continuity.

*e. Signal Monitoring.* Measure the current of each transmitting loop while the equipment is in operation by connecting the INPUT jack of the LOOP CURRENT METER to the appropriate loop MONITOR jack of the associated transmitter. The normal marking current is 20 ma or 60 ma as required by the external transmitting telegraph equipment in the transmitting loop. Measure signal levels while the equipment is in operation by connecting the BRIDGING jacks of the LEVEL METER to the CARRIER MONITOR jacks of the transmitter and the MONITOR jacks of the SUBGROUP MODULATOR and the LEVEL CONTROL & PLATE SUPPLY. The normal signal levels for the CARRIER MONITOR jacks of the various transmitters channels are those recorded as instructed in paragraph 107. The correct level for the DIRECT PATH and TRANSLATED PATH INPUT BUS jacks of the SUBGROUP MODULATOR for eight channels is −6 dbm ±1 db. The correct level for the INPUT MONITOR jacks of the LEVEL CONTROL & PLATE SUPPLY is −33 dbm ±1 db and for the OUTPUT MONITOR jacks +2 dbm for space diversity operation and +8 dbm for frequency diversity operation.

*f. Listening Tests.* Listening tests can be made while the equipment is in operation by connecting Electrical Headset H–110/G to the CARRIER MONITOR jacks of the transmitters or to the desired MONITOR jacks of the SUBGROUP MODULATOR and LEVEL CONTROL & PLATE SUPPLY. Listen for normal signal tones and any abnormal indications, such as excessive noise or intermittent interruptions.

## 116. Operating Procedure, Transmitting Vf Circuits

The transmitting vf circuits in cabinet 1 of the transmitting terminal may require certain patching operations when traffic assignments are changed. Perform monitoring checks periodically to determine if circuit conditions are normal to maintain a high degree of service continuity.

*a. 3KC SEND BAND TEST PANEL.* When the multiplexers are installed at the remote radio transmitter site, use the jack groups of the 3KC SEND BAND TEST PANEL for routing circuits when traffic assignments are changed and also for measuring and monitoring the vf circuit signals. Each jack group (designated jack groups 1 through 4) is permanently connected into one of the transmitting vf circuits. Use the EQUIP. OUT jacks associated with transmitting telegraph, telephone, or facsimile equipment to patch this equipment to a different vf transmission circuit by way of the LINE IN jacks of the appropriate jack group. Use the MONITOR jacks, connected across the circuit at the output of each jack group with respect to the signal path, to connect the BRIDGING jacks of the LEVEL METER on the TRANSMITTER METER PANEL to the vf circuits for level measurements, and also to connect Electrical Headset H–110/G to these circuits for listening tests.

*b. Multiplexer TD–97/FGT–2.* When the multiplexers are installed in the transmitting terminal, use the LINE and EQUIP jack pairs on the multiplexers for patching operations when traffic assignments are changed. Use the INPUT LINE jacks associated with transmitting telegraph, telephone, or facsimile equipments to patch this equipment to a different multiplexer input circuit by way of the appropriate INPUT EQUIP jacks. The OUTPUT EQUIP jacks can be used to patch the output of the associated multiplexer to a different outgoing 6-kc line to the radio transmitter site. Perform level measurements by connecting the BRIDGING jacks of the LEVEL METER on the TRANSMITTER METER PANEL to the MONITOR jacks. Perform listening tests by connecting Electrical Headset H–110/G to the MONITOR jacks. Listen for normal signal tones and any abnormal indications, such as excessive noise or intermittent interruptions. When traffic assignments are changed, do not alter the position of the OUTPUT LEVEL ADJUST control. The correct setting remains the same for telegraph, telephone, or facsimile service (par. 108 *b* and *c*). To change the frequency diversity or space diversity routing system, arrange the strapping connections on terminal board TB9 of the multiplexer for the desired routing option (pars. 54 through 57). To reach the strapping connections, remove the front-panel cover over terminal board TB9.

*Note.* Always use the MONITOR jacks when making level measurements or listening tests on operating circuits to avoid disrupting transmission. LINE or EQUIP jacks cannot be used without interrupting service.

## 117. Operating Procedure, Receiving Vf Circuits

The receiving vf circuits in cabinet 3 of the receiving terminal may require certain patching operations whenever traffic assignments are changed. Perform monitoring checks periodically to maintain a high degree of service continuity.

*a. 3KC RECEIVE BAND TEST PANEL.* Perform all patching operations for changing traffic assignments of 3-kc circuits at the jack groups of the 3KC RECEIVE BAND TEST PANEL. The jack groups (designated jack groups 1 through 8) are permanently connected into the receiving vf circuits. Use the LINE OUT jacks to patch an incoming vf circuit to different receiving telegraph, telephone, or facsimile equipment by way of the EQUIP IN jacks of the appropriate jack group. Use the MONITOR jacks for level measurements of the vf circuits (in conjunction with the BRIDGING jacks of the LEVEL METER of the RECEIVER METER PANEL) and also to connect Electrical Headset H–110/G to these circuits for listening tests.

*b. Demultiplexer TD–98/FGR–3.* When the demultiplexers are installed at the receiving terminal, perform the patching and monitoring operations for 3-kc circuits at the 3KC RECEIVE BAND TEST PANEL (*a* above). Use the INPUT LEVEL ADJUST control to protect the demultiplexer circuits from overload. This control is normally set in position 50. Do not readjust it unless excessively high input levels are encountered. To protect the demultiplexer from overloading, reduce the setting of the INPUT LEVEL ADJUST control if the input level exceeds +5 dbm, as measured in the INPUT MONITOR jacks. Determine and correct the cause of the excessively high input level. The OUTPUT LEVEL ADJUST controls of the demultiplexer should not require readjustments unless the traffic assignments are changed. The correct level adjustment differs for telephone, telegraph, or facsimile service. Whenever a change is made in the type of service assigned to one of the demultiplexer signal paths, a change must be made in the corresponding OUTPUT LEVEL ADJUST control. Make the readjustments as indicated in the line-up procedure in paragraph 110*b* and *c*. The INPUT LINE jacks can be used to patch the incoming signals to the input of a different demultiplexer by way of the associated INPUT EQUIP jacks.

*c. Audio Frequency Amplifier AM–911/FG.* Do not disturb the equalizer or LEVEL ADJUST controls of the audio-frequency amplifier unless a complete line-up is to be performed. Make level measurements and listening tests at the AMPLIFIER A and AMPLIFIER B MONITOR jacks. AMPLIFIER A and AMPLIFIER B are used independently, and may be lined up for different types of interconnecting facilities between the radio receiver site and the communication center, so that the AMPLIFIER A and AMPLIFIER B LEVEL ADJUST and equalizer controls may have different settings. The OUTPUT EQUIP jacks of AMPLIFIER A or AMPLIFIER B can be used to patch the output of the amplifier to the outgoing line of a different AMPLIFIER A or AMPLIFIER B by way of the associated OUTPUT LINE jacks. The INPUT EQUIP jacks of AMPLIFIER A or AMPLIFIER B can be used to patch the input circuit of the amplifier to a different incoming line from the radio receiver site. Do not patch a different line to the INPUT EQUIP jacks unless the new line has the same electrical characteristics as the line for which the amplifier was lined up.

*Note.* Always use MONITOR jacks when making level measurements or listening tests on an operating circuit to avoid discontinuity of reception. Use of LINE or EQUIP jacks interrupts service.

## 118. Operating Procedures, Telegraph Receiver Group

*a. Operation of Receiving Loops.* The receiving loops of the telegraph receiver group are always operated from −130 volts loop battery to ground. Arrange the combiner channels for operation with either 20 ma or 60-ma loop current, as follows:

(1) For a receiving loop that requires a 20 ma-operating current, set the LOOP CURRENT switch of the associated combiner channel in the 20 MA position and for a loop that requires a 60-ma current, set the switch in the 60 MA position.

(2) Apply a marking signal to the receiving loop by setting the IDLE-NORMAL switch of the associated combiner channel in the IDLE position.

(3) Select the proper sensitivity for the LOOP CURRENT METER panel by operating the 90MA–30 MA switch (fig. 68) to the appropriate position

(30 MA position for 20 ma loops and 90 MA position for 60 ma loops).

(4) Connect the INPUT jack of the LOOP CURRENT METER to the loop MONITOR jack of the associated combiner channel and set the loop current to 20 ma or 60 ma with the appropriate LOOP CURRENT ADJUST control.

*Note.* The IDLE-NORMAL switch of the combiner channel must be set in the NORMAL position for telegraph signals to be transmitted to the receiving loop. When in the IDLE position the receiving loop is held in the marking (closed) condition.

*b. Diversity Operation of Telegraph Receiver Group.* The AN/FGC–29 terminal normally operates in two-channel diversity to provide 16 teletypewriter circuits. To maintain communications when two-channel diversity is unsatisfactory, four-channel diversity may be used. Any or all of COMBINER CHANNELS 1 and 2 through COMBINER CHANNELS 15 and 16 may be operated in four-channel diversity. When operating in four-channel diversity service on the even-numbered loop, circuit is interrupted to maintain service on the odd-numbered loop circuit. For this reason high priority circuits should be assigned to odd-numbered loops. When all combiners are operated in four-channel diversity, only eight teletypewriter circuits are available for use in the receiving direction.

(1) *Two-channel to four-channel.*

(*a*) Make sure that both DISCRIMINATOR switches of the combiner are set in the same position.

(*b*) Operate the DIVERSITY switch on the combiner involved to the 4-CHANNEL, loop 1 only position. This switch may be operated manually at the equipment or electrically from a remote control station.

(*c*) See that the corresponding transmitter at the distant terminal is arranged for four-channel diversity operation.

(2) *Four-channel to two-channel.*

(*a*) Operate the DIVERSITY switch on the combiner involved to the 2-CHANNEL, LOOPS 1 and 2 position. This switch may be operated manually at the equipment or electrically from a remote control station.

(*b*) See that the corresponding transmitter at the distant terminal is arranged for for two-channel diversity operation.

*c. Use of Controls.* After the telegraph receiver group has been lined up (par. 111) and the receiving loop currents properly adjusted (*a* above), only the DIVERSITY switches of the combiners are required to be used during normal operation. Do not disturb the remaining controls of the combiners or the controls of the receivers and SUBGROUP MODULATORS.

*d. Use of Jacks.* In the telegraph receiver group are single jacks that are used with cords equipped with single plugs, which are associated with dc telegraph circuits, and twin jacks that are used with cords equipped with twin plugs, which are associated with carrier telegraph circuits.

(1) On the front panel of each combiner are two groups of jacks associated with the telegraph receiving loops. In each group is a LOOP jack, an EQUIP jack, and a MONITOR jack. Use the LOOP and EQUIP jacks and patching cords equipped with single plugs for making changes in telegraph circuit routing. The LOOP jack allows a connection to be made to the associated loop and permits it to be patched to a different EQUIP jack. The EQUIP jack allows a connection to be made to the output circuit of a combiner and permits it to be patched to a different LOOP jack. Whenever a patch is made, the receiving loop should be checked for proper operation (*a* above). Connections to the LOOP or EQUIP jacks cannot be made without interrupting the telegraph circuit. The MONITOR jack is in series with the output of the jack group with respect to the signal path. It permits the LOOP CURRENT METER to be connected in series with the external loop without interrupting its continuity.

(2) On the front panel of each receiver are two groups of jack pairs associated with RECEIVER A and RECEIVER B used with cords equipped with twin plugs. In each group are a pair of LINE jacks which permit the input of the receiver to be connected to the BRIDGING jacks of the LEVEL METER for a meter indication of the receiver input signal

level. The EQUIP jacks remove the input of the receiver channel from its associated bus and permit a connection to be made to the input circuit of the receiver channel for the introduction of test signals. The LINE and EQUIP jacks cannot be used without interrupting the circuit. The MONITOR jacks permit the BRIDGING jacks of the LEVEL METER to be connected to internal test points in the receiver channel (fig. 54) without interrupting the circuit to see that the proper signal level is being received. The METER jacks, in association with the METER SWITCH, permit the BRIDGING jacks of the LEVEL METER to be connected to internal test points in RECEIVER A or RECEIVER B to check their operation without interrupting the circuits.

(3) On the front panel of SUBGROUP DEMODULATOR A and SUBGROUP MODULATOR B are a pair of LINE jacks, a pair of EQUIP jacks, and a pair of MONITOR jacks associated with the INPUT circuits. The LINE jacks permit connection to the incoming line for measurement of the received multichannel telegraph signal level. The EQUIP jacks permit connection to the input circuit of the SUBGROUP DEMODULATOR for the introduction of test signals. The LINE and EQUIP jacks cannot be used without interrupting the circuit. The MONITOR jacks are connected across the circuit at the output of the jack group with respect to the signal path. They permit the BRIDGING jacks of the LEVEL METER to be connected across the circuit for measurement of the received signals without interrupting the circuit.

*e. Signal Monitoring.* Measure the current of each receiving loop while the equipment is in operation by connecting the INPUT jack of the LOOP CURRENT METER to the appropriate loop MONITOR jack of the associated combiner channel. The normal marking current is 20 ma or 60 ma as required by the external receiving telegraph equipment in the receiving loop. Measure signal levels while the equipment is in operation by connecting the BRIDGING jacks of the LEVEL METER to the MONITOR jacks or METER jacks of the receivers and to the MONITOR jacks of the SUBGROUP DEMODULATORS.

## 119. Operation of Telegraph Order-Wire Circuit

One of the four vf circuits of the AN/FGC–29 terminal is normally available for a telephone order-wire circuit between the two terminals of the system. When telephone order-wire facilities are not available, telegraph order-wire service can be established by using one of the telegraph channels of the AN/FGC–29 terminals Proceed as follows:

*a. Transmitting Terminal.*

(1) Connect the sending circuit of a teletypewriter to the EQUIP jack of the transmitter channel selected for order-wire service.

(2) Set the LOOP TERMINATION switch of the transmitter channel in the GRD position and the LOOP CURRENT SELECTOR switch to 60MA

(3) Connect the LOOP CURRENT METER to the loop MONITOR jack of the transmitter channel and set the marking loop current to 60 ma with the LOOP CURRENT ADJUST control.

*b. Receiving Terminal.*

(1) Connect the receiving circuit of the teletypewriter to the EQUIP jack of the combiner channel selected for order-wire service.

(2) Set the LOOP CURRENT switch of the combiner channel to the 60 MA or 20 MA position to meet the corresponding current rating of the particular teletypewriter used. Set the DISCRIMINATOR switch in the NORMAL position.

## 120. Emergency Operation

The AN/FGC–29 terminal can be continued in complete service despite the failure of some of its units by using the fallback procedures listed in subparagraphs *a* through *c* below. When the failed unit is repaired, place it back in service by restoring the fallback switches to their normal positions.

*a.* Each loop battery supply in the transmitting and receiving terminals is capable of supplying 16 telegraph loops. Normally, RECTIFIER A is arranged by the LOAD A fallback switch on the LOOP BATTERY PANEL (fig. 75) to supply

loops 1 through 8, and RECTIFIER B is arranged by the LOAD B fallback switch to supply loops 9 through 16. If either loop battery supply fails, indicated by RECTIFIER A or RECTIFIER B FAILURE INDICATOR, place the full load of 16 loops on the remaining loop battery supply. Do this by setting both LOAD A and LOAD B FALL BACK SWITCHES in the RECT A or RECT B position corresponding to the operating loop battery supply.

*b.* Each plate supply in the LEVEL CONTROL & PLATE SUPPLY is capable of supplying B-plus and heater voltage for both amplifiers of this component, and B-plus voltage for transmitter channels 1 through 16. Normally, channels 1 through 8 and amplifier A are supplied by plate supply A, and channels 9 through 16 and amplifier B by plate supply B. If either plate supply fails, indicated by PLATE SUPPLY A FAILURE or PLATE SUPPLY B FAILURE indicator, the load of the failed plate supply can be transferred to the remaining supply. Do this by setting both the CHANNELS 1–8 and AMPL A switch and the CHANNELS 9–16 and AMPL B switch to the A or B position corresponding to the operating plate supply.

*c.* There are two line amplifiers in the LEVEL CONTROL & PLATE SUPPLY. Amplifier A is normally in use and amplifier B is available as a fallback for amplifier A (or for use in the line-up or maintenance of the AN/FGC–29 terminal). If amplifier A fails, it can be replaced with amplifier B to maintain operation of the transmitting terminal. To do this, set the AMPLIFIER IN USE switch to the B position.

*d.* There are three voltage regulators in the AN/FGC–29 terminal. If a voltage regulator fails, full service can be maintained by disconnecting the failed regulator from the power circuit and operating on unregulated power. To do this, set the OUTPUT VOLTAGE switch on the associated AC POWER SWITCHING PANEL of the failed regulator to the UNREG position. Remove power to the regulator by setting the VOLTAGE REGULATOR switch to the OFF position.

## 121. Operation Under Severe Fading Conditions

Fading or noise conditions on the radio circuit may become so severe that four-channel diversity is inadequate to permit satisfactory operation. Under such conditions, telegraph service may be maintained by limiting communication to fewer channels. By halting transmission on the remaining channels, the radio transmitter power required for these channels can be concentrated in the channels still in use with a corresponding improvement in performance. Proceed as follows:

*a. Transmitting Terminal.*

(1) Place the IDLE-NORMAL switches of the unused transmitters in the IDLE position to eliminate signal output from these transmitters.

(2) Operate in four-channel diversity those transmitters on which service is to be maintained. Only the odd-numbered transmitting loops can be used. Set the DIVERSITY switches of the transmitters associated with these loops in the 4 CHANNEL loop 1 only position.

(3) Set the LEVEL ADJUST control on the LEVEL CONTROL & PLATE SUPPLY for an output level (measured at the OUTPUT MONITOR jacks) of +2 dbm for space diversity operation and +8 dbm for frequency diversity. If service on the telephone and facsimile vf circuits is suspended, it may be possible to increase the output level by an additional 3 db.

*b. Receiving Terminal.*

(1) Set the IDLE-NORMAL switches of the unused combiners in the IDLE position to hold the receiving loops of these channels in the closed (marking) condition.

(2) Operate in four-channel diversity those combiners on which service is to be maintained. Only the odd-numbered receiving loops can be used. Set the DIVERSITY switches of the combiners associated with these loops to the 4-CHANNEL LOOP 1 ONLY position.

(3) Set the signal level (as measured at the OUTPUT MONITOR jacks of the demultiplexer paths carrying telegraph signals) as indicated in the table below. Use the associated OUTPUT LEVEL ADJUST controls. When the demultiplexers are located at the radio receiving site, do not change the OUTPUT LEVEL ADJUST controls. In this case, set the signal level (as measured in the OUTPUT MONITOR jacks of AMPLIFIER A or AMPLIFIER B of audio-frequency amplifiers in the receiving terminal carrying telegraph signals) as indicated in the table below. Use the

associated LEVEL ADJUST controls of the audio frequency amplifiers. Selective fading may cause the readings to fluctuate; use the maximum reading as the indicated signal level.

| Number of channels in use | Signal level (dbm) |
|---|---|
| 2 | +3 |
| 4 | +6 |
| 6 | +7.5 |
| 8 | +9 |
| 10 to 16 | +12 |

### 122. Stopping Procedure

To deenergize the AN/FGC–29 terminal, proceed as follows:

*a.* Set the OUTPUT VOLTAGE switches on the AC POWER SWITCHING PANELS in cabinets 2, 4, and 6 to the UNREG position.

*b.* Set the ON-OFF power switches on the main power units at the bottom rear of cabinets 1, 3, and 5 to the OFF position. The OUTPUT VOLTAGE meters on the ac power switching panels should indicate zero.

## Section VI. OPERATION UNDER UNUSUAL CONDITIONS

### 123. General

The AN/FGC–29 terminal is fixed plant equipment usually operated in permanent buildings at normal room temperatures. Such shelters may not always be available in regions where extreme cold, heat, humidity and moisture, or sand conditions prevail. Paragraphs 124 through 126 contain instructions for minimizing the effect of these unusual operating conditions.

### 124. Operation in Arctic Climates

Subzero temperatures and climatic conditions associated with cold weather affect the efficient operation of the AN/FGC–29 terminal. Instructions and precautions for operation under such adverse conditions follows:

*a.* Handle the equipment carefully. Extreme cold makes parts brittle and increases the chance of breakage.

*b.* Keep the equipment warm and dry. Keep the power on and the tube heaters lighted.

*c.* Do not allow cold drafts to come in contact with the glass envelope of a heated tube; the cold draft may shatter it. Operate the equipment with the drawers in place within the cabinets and the rear doors of the cabinets closed.

*d.* When equipment that has been exposed to the cold is brought into a warm room, it will sweat until it reaches room temperature. When it reaches room temperature, dry it thoroughly.

### 125. Operation in Tropical Climates

When the AN/FGC–29 terminal is operated in tropical climates where fixed-plant housing facilities are not available it may be installed in improvised shelters or huts. When the equipment is installed in an improvised shelter in swampy areas, moisture conditions are more acute than normal in the tropics. Ventilation is usually very poor, and the high relative humidity causes condensation of moisture on the equipment whenever the temperature of the equipment becomes lower than the temperature of the surrounding air. To minimize this condition, operate the equipment with the drawers in place in the cabinet, and keep the rear of the cabinet closed. Clean the air filters regularly and make sure the vents on the top and rear of each cabinet are free from obstructions that might impede the flow of air. Very rapid growth of fungi is one result of excessive humidity. Keep the power on and the tube heaters lighted.

### 126. Operation in Desert Climates

*a.* Conditions similar to those encountered in tropical climates often prevail in desert areas. Use the same measures to insure proper operation of the equipment.

*b.* The main problem which arises with equipment operation in desert areas is the large amount of sand or dust and dirt which enters the building. The equipment should be enclosed in a dustproof shelter. If such a building is not available, make the shelter as dustproof as possible with available materials.

*c.* The equipment should be kept free from oil and grease which may combine with dust, sand, or dirt to form grit, which will damage the equipment.

# CHAPTER 4
# THEORY

## Section I. INTRODUCTION

### 127. General

Telegraph Terminal AN/FGC–29 is used in long distance communication systems that include single-sideband radio transmitters and receivers and interconnecting wire line facilities. The AN/FGC–29 terminal provides equipment for 16 teletypewriter circuits (plus multiplexing and line equalizing equipment) to permit simultaneous use of the radio circuit for telegraph, telephone, and facsimile transmission.

### 128. General Function of Telegraph Transmitter Group

The telegraph transmitter group provides facilities for generating 16 frequency-shift carrier telegraph channels spaced at 170-cycle intervals from 425 to 2,975 cps. Frequency-shift telegraphy is a form of frequency modulation in which signaling is accomplished by shifting a constant amplitude carrier between two frequencies representing the marking and spacing conditions of the telegraph code. The dc telegraph signals in each of the 16 sending telegraph loops shift the frequency of an associated transmitting oscillator by suitably varying the frequency determining elements of the oscillator circuit. The resulting 16 carrier telegraph channels are divided into two groups of 8 channels each. The channels in each group are spaced at 170-cycle intervals from 1,785 to 2,975 cps. Channels in one group are assigned odd channel numbers from 1 to 15 and leave the telegraph transmitter group without frequency translation. Channels in the other group are assigned even channel numbers from 2 to 16. These channels are translated by the SUBGROUP MODULATOR to the frequency range 425 to 1,615 cps for transmission. The direct and translated groups are combined in the SUBGROUP MODULATOR and the 16 channels, now covering the frequency range 425 to 2,975 cps, are amplified in the LEVEL CONTROL & PLATE SUPPLY for transmission over the long-distance communication facility.

*Note.* Unless otherwise stated, the channel frequencies in this chapter are given as center frequencies. The actual channel limits are 42.5 cps above and below the center frequency, representing the marking and spacing frequencies, respectively. For example, transmitter channel 1, with a center frequency of 1,785 cps, has a bandwidth extending from 1,742.5 to 1,827.5 cps.

### 129. General Function of Telegraph Receiver Group

The telegraph receiver group accepts frequency-shift carrier telegraph signals from a distant telegraph transmitter group over a long-distance single-sideband radio circuit. Carrier telegraph channels reach the telegraph receiver group over two different paths so that diversity operation (par. 38*a*) may be used to provide reliable operation under adverse fading conditions. The carrier channels from one path enter SUBGROUP DEMODULATOR A and are converted to two groups of eight channels each. These groups are identical in frequency and channel numbers with the channels entering the SUBGROUP MODULATOR in the distant telegraph transmitter group. The carrier channels from the second path enter SUBGROUP DEMODULATOR B and are similarly converted. Each channel in the telegraph receiver group is provided with two receivers (designated RECEIVER A and RECEIVER B), which operate at the same frequency. RECEIVER A is energized by channel signals from SUBGROUP DEMODULATOR A, and RECEIVER B is energized by channel signals from SUBGROUP DEMODULATOR B. These two receivers have common control circuits, which regulate the level of the two diversity signals for optimum combining performance. The two signals then enter the combiner and pass through separate frequency discriminating circuits and are separately rectified to provide two dc telegraph signals

which are serially added to operate the receiving telegraph loop. By combining two diversity signals, reliable operation is possible through fading which may cause either of the signals to fade out completely. When fading or interference conditions are especially severe two carrier telegraph channels in the distant telegraph transmitter group may be connected to operate from a single sending loop so that both channels carry the same telegraph signals. Under these conditions, the four diversity signals of the corresponding channels in the receiving telegraph group are added in the combiner to operate a single receiving telegraph loop. This arrangement reduces the capacity of the AN/FGC–29 terminal from 16 teletypewriter circuits to 8.

## 130. General Function of Multiplexer TD–97/FGT–2

Multiplexer TD–97/FGT–2 makes it possible to combine the signals from two independent vf circuits over the same transmission medium. It is used with a single-sideband radio transmitter having a transmission bandwidth of approximately 6 kc. Each vf circuit input to the multiplexer has a bandwidth from 375 to 3,025 cps and is used to transmit carrier telegraph signals or to provide telephone or facsimile service. Signals from one vf circuit follow a path through the multiplexer designated as the direct path, and the frequencies of these signals remain unchanged. Signals from the other vf circuit follow a different path through the multiplexer designated as the translated path. Here they are shifted in frequency to a higher position in the spectrum extending from 3,265 to 5,915 cps. Frequency translation is accomplished in the multiplexer by suppressed carrier modulation and single-sideband transmission. The combined signal output of the multiplexer occupies a bandwidth between 375 and 5,915 cps. The radio transmitter associated with the multiplexer is capable of handling frequencies from 200 to 6,000 cps. Two Multiplexers TD–97/FGT–2 are required for full utilization of the capacity of a twin-channel, single-sideband radio transmitter. One is used to transmit telegraph, telephone, or facsimile signals from two vf circuits to the radio channel designated as sideband A. The second multiplexer performs the same function for sideband B. In this way four vf circuits are applied to the twin channel radio transmitter.

## 131. General Function of Demultiplexer TD–98/FGR–3

Demultiplexer TD–98/FGR–3 makes it possible to separate the signals of two vf circuits which have been combined over the same transmission medium. It is used with a single-sideband radio receiver which has a bandwidth of approximately 6 kc. Two independent vf circuits, each with a bandwidth of approximately 3 kc, are derived from the 6-kc channel of the radio receiver. The input to the demultiplexer has a bandwidth of 375 to 5,915 cps. The input signals are divided into two bands, one from 375 to 3,025 cps, and another from 3,265 to 5,915 cps. Signals in the lower range take the direct path through the demultiplexer and the frequencies of these signals remain unchanged. Signals in the upper range follow a different path through the demultiplexer designated as the translated path. Here they are shifted to a lower position in the frequency spectrum extending from 375 to 3,025 cps. Frequency translation is accomplished in the demultiplexer by suppressed carrier modulation and single-sideband transmission. The outputs of the demultiplexer are two 375 to 3,025 cps vf circuits which are used to receive carrier telegraph signals, or to provide telephone or facsimile service. Two Demultiplexers TD–98/FGR–3 are required for full utilization of the capacity of a twin-channel, single-sideband radio receiver. One is used to receive telegraph, telephone, or facsimile signals for two vf circuits from the radio channel designated as sideband A. The second demultiplexer performs the same function for sideband B. In this way, four vf circuits are derived from the twin-channel radio receiver.

## 132. General Function of Audiofrequency Amplifier AM–911/FG

Audiofrequency Amplifier AM–911/FG compensates for the loss characteristics of loaded or nonloaded pairs in cables of the lead-covered, paper-insulated type. The audiofrequency amplifier contains two identical transmission paths, designated as amplifier A and amplifier B, which provide equalization, amplification, and impedance matching for two line circuits. The audiofrequency amplifier supplies adjustable equalization and amplification in each path to offset the loss characteristic up to 20 miles of 19-gage non-

loaded cable, and varying lengths of other non-loaded cables from 300 to 6,000 cps (par. 15*c*). Each path of the audiofrequency amplifier supplies equalization and amplification up to 40 miles of 19-gage H–44 loaded cable, and for varying lengths of other loaded cable (par. 15*d*), from 300 to 3,500 cps. The audiofrequency amplifier inputs contain line-matching transformers which present input impedances of 150, 600, or 1,350 ohms to the line. Each amplifier may be used without equalization to provide a flat gain of 0 to 50 db from 300 to 6,000 cps.

## 133. Theory of Single-Sideband Operation

*a. Sky-Wave Transmission.* Radio circuits used to provide long-distance communication are commonly operated in the high-frequency range between 3 and 30 megacycles. The propagation of hf radio waves utilizes the refractive properties of the ionosphere, located from 60 to 300 miles above the earth, to achieve transmission over distances as long as several thousand miles. This method of radio propagation is referred to as sky-wave transmission.

*b. Selective Fading.* The transmission quality of a sky-wave radio system depends upon conditions in the ionosphere between the radio transmitter and receiver sites. In general, multipath effects prevail where the radio wave travels to the receiver along different paths simultaneously. The paths are continually varying in length, and the received signals are subject to fading caused by cancellation between signal waves coming in over different paths. If the path lengths differ greatly, the fading becomes selective in that different frequencies in the signal band do not all fade at the same time. At any particular instant some frequencies are present at normal levels while others are severely attenuated. The fading pattern shifts continually, and any given frequency experiences wide and rapid level variations from one instant to the next.

*c. Single-Sideband Transmission.* A conventional amplitude-modulated radio system employing double-sideband transmission is subject to severe distortion under conditions of selective fading. At times, the fading reduces the radio-frequency carrier relative to the sidebands, resulting in a suppression of the fundamental signal frequencies at the radio receiver output and the introduction of second harmonics caused by the beat between the upper and lower sidebands. Single-sideband radio operation is one method of eliminating such distortion. In this method one sideband is removed at the transmitter and the carrier component is largely suppressed. At the receiver, the carrier component is selected and used to control the frequency of a locally generated carrier of constant amplitude. This local carrier is then used to demodulate the received single-sideband signal. The local carrier is always present and is not affected by selective fading; therefore, the distortion experienced in double-sideband transmission cannot occur. Suppression of the carrier and one sideband allows concentration of the available transmitter power in the remaining single sideband to effect further improvement in radio circuit performance. Twin-channel systems are derived by using the spectrum formerly occupied by the suppressed sideband to carry a second and independent intelligence channel. A twin-channel system comprises two single-sideband systems that have a common carrier frequency. One channel uses the sideband below the carrier, and the other uses the sideband above the carrier.

## 134. Theory of Diversity Radio Operation

Single-sideband transmission eliminates the harmonic distortion present in a double-sideband system but does not overcome the variations in received level caused by fading. Automatic telegraph operation on long-range radio circuits is generally unsatisfactory unless diversity operation is provided to reduce the effect of selective fading. The two preferred methods, used singly or in combination, are frequency diversity and space diversity operation.

*a. Frequency Diversity.* In frequency diversity operation, the fading patterns of two radio frequencies, separated by at least 600 or 700 cps, are essentially uncorrelated. To use their random relationship, each telegraph channel is transmitted simultaneously on two radio frequencies. If both received signals are properly combined to operate a single telegraph circuit, transmission errors will not occur as long as either frequency is being received. Because the probability of both signals fading at the same time is small compared to the probability of one frequency fading, the result is a great improvement in circuit performance.

*b. Space Diversity.* Space diversity operation is based on the fact that a random relationship exists between the selective fading patterns at two antennas physically separated by several wave lengths. Each telegraph channel is transmitted

on a single frequency and the outputs of two radio receivers associated with two different antennas are combined to operate one telegraph circuit. An improvement results because the probability of a particular frequency fading at both antennas at the same time is small. In some cases, both frequency and space diversity may be employed simultaneously to obtain even greater reliability.

*c. Ratio-Squaring Diversity Combining.* The AN/FGC–29 terminal uses the ratio-squaring diversity combining principle to reduce the effects of selective fading. This combining system takes advantage of the fact that the fading patterns of the diversity signals are essentially uncorrelated and also provides a combined signal of improved signal-to-noise ratio to operate the receiving telegraph loop. When the two diversity carrier signals are received at equal levels and are converted to dc telegraph signals, the converted signals are also of equal amplitude. Because the duration of a telegraph dot at 100 wpm is long compared to the maximum time displacement between the diversity signals introduced by the radio transmission path, the two dc telegraph signals are always essentially in phase. Therefore, when these signals are connected in series aiding they add arithmetically to produce a resultant signal of twice the amplitude of either individual signal. This is equivalent to a 6-db increase in signal level. In a multichannel carrier telegraph system, the average random noise accompanying each received carrier signal is essentially at the same level, regardless of the particular carrier frequency of the signal. The noise is random; thus, no correlation exists between the two noise components associated with the diversity signals to be combined. Therefore, the two noise components add on a root mean square, or power basis, instead of arithmetically as the telegraph signals. As a result, the noise level after combining is 3 db greater than the noise associated with either diversity signal. Since the diversity signals combine to produce a 6-db increase and the two noise components combine to produce only a 3-db increase, an improvement of 3 db in the signal-to-noise ratio is obtained. A further 3-db improvement in the signal-to-noise ratio results whenever the number of diversity signals being combined is doubled, if all the signals are of equal level and all the noise components are also equal. When the two diversity signals to be combined are received at different levels, due to selective fading, the level ratio of the signals as received must be altered before combining. The optimum signal-to-noise ratio after combining is obtained by squaring the ratio of the diversity signals. For example, if the ratio of the signals as received is 2 to 1 (6 db), this ratio must be increased to 4 to 1 (12 db) before combining. This is done by maintaining the larger signal at a fixed level and decreasing the level of the smaller signal by the required amount to obtain the desired ratio. The amount by which the signal-to-noise ratio is increased after combining depends upon the ratio of the received signals. If the ratio of the signals is unity, the ratio after squaring is still unity, and a 3-db improvement in the signal-to-noise ratio is obtained as described above. If the ratio of the signals is 6 db then a 1-db improvement is realized. If the ratio of the received signals is 20 db or more, then the ratio after squaring is 40 db or more. Thus, the smaller signal and its associated noise are substantially eliminated, and the signal-to-noise ratio after combining is essentially the same as the signal-to-noise ratio of the larger signal. The ratio-squaring diversity combining circuits are located partially in the receiver and partially in the combiner and are discussed in detail in paragraphs 180 through 193.

## Section II. GENERAL THEORY, AN/FGC–29 TERMINAL

### 135. General

The AN/FGC–29 terminal comprises terminal equipment for a 16-channel, frequency-shift, carrier telegraph system, and voice-frequency multiplexing facilities for use with long-distance twin-channel, single-sideband radio communication circuits. The multiplexing facilities permit the simultaneous transmission of telegraph, telephone, and facsimile signals over the radio circuit. Line equalizing equipment is included in the AN/FGC–29 terminal to permit the use of 3- or 6-kc wire line circuits between the terminal and remotely located radio transmitter and receiver sites. The multiplexing and line equalizing equipment is operable either as part of the terminal, or as part of the radio equipment, as required by the particular system layout.

## 136. General Theory, Transmitting Terminal, 6-kc Lines

Figure 250 is a block diagram of the AN/FGC–29 terminal arranged for use with 6-kc line facilities. The transmitting terminal consists of cabinets 1 and 2 and is shown at A in the figure. When operating with 6-kc line facilities, multiplexers 1 and 2 are located in cabinet 1. One of the two audiofrequency amplifiers mounted in cabinet 1 is removed and installed for use at the radio transmitter site. The second audiofrequency amplifier in this cabinet is not used in this application of the AN/FGC–29 terminal.

*a. Telegraph Transmitter Group.* The eight transmitters in cabinet 2, each contains frequency-shift carrier generating circuits for two channels. The channel frequencies and designation for each transmitter are shown in figure 254. The dc telegraph signals in each transmitting loop control the frequency of an associated carrier oscillator. The frequency is shifted 42.5 cps above the nominal channel frequency for a marking signal and 42.5 cps below the nominal channel frequency for a spacing signal. The eight odd-numbered carrier channels 1 through 15 are spaced 170 cycles apart and cover the frequency range 1,785 to 2,975 cps. The output carrier signals from the odd-numbered channels are applied to the odd channel send bus and enter the direct path of the SUBGROUP MODULATOR. The eight even-numbered carrier channels 2 through 16 are also spaced 170 cycles apart and cover the same frequency range. The output carrier signals from the even-numbered channels are applied to the even channel send bus and enter the translated path of the SUBGROUP MODULATOR. The odd-numbered channel signals pass through the SUBGROUP MODULATOR directly without frequency translation. The even-numbered channel signals are translated from the 1,785- to 2,975-cps range to the 425- to 1,615-cps range and join the untranslated odd-numbered channels in the output circuits of the SUBGROUP MODULATOR. The 16-channel signals, now covering the frequency range from 425 to 2,975 cps and spaced 170 cycles apart, are applied to the input of the LEVEL CONTROL & PLATE SUPPLY. A line amplifier in the LEVEL CONTROL & PLATE SUPPLY increases the power of the carrier signals to the level required for transmission Two-plate supplies in the LEVEL CONTROL & PLATE SUPPLY furnish plate voltage to the transmitters (par. 169). Output signals from the LEVEL CONTROL & PLATE SUPPLY pass from cabinet 2 to cabinet 1 and enter the 3KC SEND BAND TEST PANEL.

*b. Multiplexing Equipment.* The carrier telegraph signals from cabinet 2 pass through jack group 1 of the 3KC SEND BAND TEST PANEL and are applied to the direct path input of multiplexer 1. Vf signals from three external telephone or facsimile terminal equipments to be transmitted over the radio circuit enter cabinet 1 and pass through jack groups 2, 3, and 4 and are applied respectively to the translated path of multiplexer 1 and the direct and translated paths of multiplexer 2. The 3KC SEND BAND TEST PANEL provides a central test position for monitoring or patching the signals of all four 3-kc vf circuits to be transmitted over the radio circuit. The vf signals entering the direct paths of the multiplexers are transmitted without frequency translation. The signals entering the translated paths are translated to the range from 3,265 to 5,915 cps. The output frequency band of each multiplexer extends from 375 to 5,915 cps and contains the signals for two vf circuits. The input circuits of the multiplexers are capable of being interconnected to permit rerouting of the vf circuits if required. The output signals from multiplexers 1 and 2 pass through transformers T1 and T3, respectively, in Transformer Assembly TF–206/FG (par. 201) to the 6-kc lines for transmission to the radio transmitter site. Transformers T1 and T3 match the output impedance of the multiplexer to the impedance of the line circuits.

## 137. General Theory, Receiving Terminal, 6-Kc Lines

The receiving terminal comprises cabinets 3 through 6 and is shown, arranged for operation with 6-kc line facilities at B in the block diagram of figure 250. In this application audiofrequency amplifiers 1 and 2 and demultiplexers 1, 2, and 3 are mounted in cabinet 3 of the AN/FGC–29 terminal.

*a. Demultiplexing Equipment.* Signals over two 6-kc lines from the radio receiver site enter cabinet 3 and pass to transformers T1 and T3 in Transformer Assembly TF–206/FG No. 1. Signals over a third 6-kc line from the radio receiver site enter cabinet 3 and pass to transformer T1 in Transformer Assembly TF–206/FG No. 2. The transformers match the impedance of the 6-kc lines to

the impedance of audiofrequency amplifiers 1 and 2. Amplifiers and equalizing networks in audiofrequency amplifiers 1 and 2 compensate for the loss and frequency characteristic of the 6-kc lines, and pass the equalized signals to demultiplexers 1, 2, and 3. Each demultiplexer accepts a frequency band from 375 to 5,915 cps (containing two superimposed 375- to 3,025-cps vf circuits) and delivers two separate vf circuits, each extending from 375 to 3,025 cps. Demultiplexers input signals in the direct path frequency band from 375 to 3,025 cps pass to the direct path output without frequency translation. Demultiplexer input signals in the translated path frequency band from 3,265 to 5,915 cps are translated to a 375- to 3,025-cps band and appear at the translated path output. Telephone or facsimile signals in the vf circuits from the translated path of demultiplexer 1 and the direct and translated paths of demultiplexer 2 pass through jack groups 2, 3, and 4, respectively, in the 3KC RECEIVE BAND TEST PANEL to external telephone or facsimile terminals. The 3KC RECEIVE BAND TEST PANEL provides a central test position for monitoring or patching the received signals of all 3-kc vf circuits. Telegraph signals from one radio transmission path appear at the direct path output of demultiplexer 1 and pass through jack group 1 in the 3KC RECEIVE BAND TEST PANEL to the input of SUBGROUP DEMODULATOR A in cabinet 5. Telegraph signals from a second radio transmission path appear at the direct path output of demultiplexer 3 and pass through jack group 5, in the 3KC RECEIVE BAND TEST PANEL, to the input of SUBGROUP DEMODULATOR B in cabinet 5. The translated path of demultiplexer 3 is not used in this application of the AN/FGC–29 terminal. Two additional vf circuits from the radio receiver site can be made available by installing a fourth demultiplexer (not supplied with the AN/FGC–29 terminal) in place of dummy circuit panel 4 (par. 59). Signals over a fourth 6-kc line pass through impedance matching transformer T3 in Transformer Assembly TF–206/FG No. 2 (par. 201) to equalizing networks in audiofrequency amplifier 2. The equalized signals from audiofrequency amplifier 2 are applied to the fourth demultiplexer. The two vf circuits from the demultiplexer pass through jack groups 7 and 8 in the 3KC RECEIVE BAND TEST PANEL to external telephone or facsimile terminal equipment.

*b. Telegraph Receiver Group.* The telegraph receiver group consists of cabinets 4, 5, and 6. The odd-numbered telegraph channel signals from 1,785 to 2,975 cps entering SUBGROUP DEMODULATOR A in cabinet 5 pass through the direct path of this unit without frequency translation and appear at the direct path output. The even-numbered telegraph channel signals in the 425- to 1,615-cps range entering SUBGROUP DEMODULATOR A pass through the translated path of this unit, and emerge at the translated path output in the 1,785- to 2,975-cps range. The odd-numbered channel frequencies from the direct path of SUBGROUP DEMODULATOR A are applied to the A path odd channel receive bus, and the even-numbered channel frequencies from the translated path are applied to the A path even channel receive bus. Similarly, the odd-numbered channels from the direct path of SUBGROUP DEMODULATOR B are applied to the B path odd channel receive bus, and the even-numbered channels from the translated path are applied to the B path even channel receive bus. Each of the 16 receivers in cabinets 4, 5, and 6 has an A path and B path input. The channel frequency and designation number for each receiver are shown in figure 255. The A path input signals for the odd-numbered channels are supplied from the A path odd channel receive bus, and the B path input signals from the B path odd channel receive bus. The A path input signals for the even-numbered channels are supplied from the A path even channel receive bus, and the B path input signals from the B path even channel receive bus. Two identical receiving filters in each receiver select the particular channel frequencies from the A path and B path receive buses, and reject all other channel frequencies. The levels of the A and B path signals are automatically adjusted for optimum combining by the receiver and are passed to an associated combiner. Eight combiners are provided in the receiving telegraph group. Each combiner contains equipment for an odd- and even-numbered channel and accepts input signals from corresponding odd- and even-numbered receivers. The A and B path frequency-shift signals from the odd-numbered receiver are each converted to dc telegraph signals and combined to operate one receiving telegraph loop. The A and B path frequency-shift signals from the even-numbered receiver are each converted to dc telegraph signals, and combined to

operate a second receiving telegraph loop. The 16-dc telegraph signals from the eight combiners pass out of cabinets 4, 5, and 6 to external telegraph loops.

## 138. General Theory, Transmitting Terminal, 3-Kc Lines

Figure 251 is a block diagram of the AN/FGC–29 terminal arranged for use with 3-kc line facilities. The transmitting terminal consists of cabinets 1 and 2 and is shown at A in the figure. When operating with 3-kc line facilities, multiplexers 1 and 2 and both audiofrequency amplifiers (all mounted in cabinet 1) are removed and installed at the radio transmitter site. Dummy circuit panels 1 and 2 are installed in the positions vacated by multiplexers 1 and 2, respectively.

*a. Telegraph Transmitter Group.* The general theory of the telegraph transmitter group (located in cabinet 2), for use with 3-kc lines is the same as for use with 6-kc lines.

*b. Voice-Frequency Circuits.* The carrier telegraph signals from cabinet 2 pass to cabinet 1 and are applied to jack group 1 in the 3KC SEND BAND TEST PANEL. Vf signals from three external telephone or facsimile terminal equipments enter cabinet 1 and are applied to jack groups 2, 3, and 4. The 3KC SEND BAND TEST PANEL provides a central test position for monitoring or patching all four 3-kc vf circuits to be transmitted. Signals from jack groups 1 and 2 pass through dummy circuit panel 1 to transformers T1 and T2, respectively, in Transformer Assembly TF–206/FG. Signals from jack groups 3 and 4 pass through dummy circuit panel 2 to transformers T3 and T4, respectively, in Transformer Assembly TF–206/FG. Transformers T1 through T4 match the 600-ohm impedances of the four vf circuits in the transmitting terminal to the impedances of the corresponding 3-kc lines to the radio transmitter.

## 139. General Theory, Receiving Terminal, 3-Kc Lines

The receiving terminal comprises cabinets 3 through 6 and is shown arranged for operation with 3-kc line facilities at B in the block diagram of figure 251. In this application, demultiplexers 1, 2, and 3 are removed from cabinet 3 and installed at the radio receiver site. Audiofrequency amplifiers 1 and 2 are installed in the positions vacated by demultiplexers 1 and 2, respectively. Dummy circuit panels 1 and 2 are installed in the positions vacated by audiofrequency amplifiers 1 and 2, respectively. A third dummy circuit panel is installed in the position vacated by demultiplexer 3.

*a. Voice-frequency Circuits.* Four 3-kc lines from the radio receiver site enter cabinet 3 and pass to transformers T1 through T4, respectively, in Transformer Assembly TF–206/FG No. 1. The transformers match the impedance of the 3-kc lines to the 600-ohm impedance of the vf circuits in the receiving terminal. Signals from transformers T1 and T2 in Transformer Assembly TF–206/FG No. 1 are fed to audiofrequency amplifier 1, and signals from transformers T3 and T4 are fed to audiofrequency amplifier 2. Signals from transformers T1 and T3 and pass through dummy circuit panel 1 to the audiofrequency amplifiers. Signals from transformers T2 and T4 pass directly to the audiofrequency amplifiers. Amplifiers and equalizing networks in audiofrequency amplifiers 1 and 2 compensate for the loss and frequency characteristic of the 3-kc lines. Telegraph signals from one radio transmission path appear at the output of audiofrequency amplifier 1 and are applied to jack group 1 in the 3KC RECEIVE BAND TEST PANEL. Telegraph signals from a second radio transmission path appear at the second output of audiofrequency amplifier 1 and are applied to jack group 2. The signals from jack groups 1 and 2 pass from cabinet 3 to cabinet 5 and are applied to SUBGROUP DEMODULATOR A and B respectively. The vf circuits from audiofrequency amplifier 2 pass through jack groups 3 and 4, respectively, in the 3KC RECEIVE BAND TEST PANEL and are extended from cabinet 3 to external telephone or facsimile terminals. Four additional vf circuits from the radio receiver site can be made available by installing audiofrequency amplifiers in place of dummy circuit panels 3 and 4 (par. 59). The additional vf circuits pass through transformers T1 through T4 in Transformer Assembly TF–206/FG No. 2 to audiofrequency amplifiers 3 and 4 either directly, or through dummy circuit panel 2. The vf circuits are equalized in the audiofrequency amplifiers and pass through jack groups 5 through 8 in the 3KC RECEIVE BAND TEST PANEL to external telephone or facsimile terminal equipment.

*b. Telegraph Receiver Group.* The general theory of the telegraph receiver group consisting of cabinets 4, 5, and 6 is the same whether the

receiving terminal is used with 6- or 3-kc line facilities (par. 137*b*).

## 140. General Theory of Auxiliary Components (figs. 250 and 251)

Three auxiliary components are included in the AN/FGC–29 terminal. These components are used for monitoring and testing during operation or maintenance of the terminal. The transmitting terminal contains a TRANSMITTER METER PANEL (*a* below), and the receiving terminal contains a RECEIVER METER PANEL (*b* below) and a DIVERSITY ALIGNMENT PANEL (*c* below).

*a. TRANSMITTER METER PANEL.* The TRANSMITTER METER PANEL, mounted in cabinet 1 of the transmitting terminal, consists of a LEVEL METER LOOP CURRENT METER, and DOTTER. The LEVEL METER is used to measure signal levels at various test points throughout the transmitting terminal. Measurements may be made on either a high-impedance bridging basis or on a 600-ohm terminating basis. The LOOP CURRENT METER is used to monitor the dc signals in the transmitting telegraph loops. The DOTTER provides a source of bias free telegraph dotting signals, which are used to key individual transmitters for channel tests and alignment.

*b. RECEIVER METER PANEL.* The RECEIVER METER PANEL, mounted in cabinet 5 of the receiving terminal, consists of a LEVEL METER, LOOP CURRENT METER, and DELAY METER. The LEVEL METER is used to measure signal levels at various test points provided throughout the receiving terminal. Measurements may be made on either a high-impedance bridging basis or a 600-ohm terminating basis. The LOOP CURRENT METER is used to monitor the dc signals in the receiving telegraph loops. The DELAY METER is used to indicate correct adjustment of the delay amplifiers in the various receivers.

*c. DIVERSITY ALIGNMENT PANEL.* The DIVERSITY ALIGNMENT PANEL, mounted in cabinet 3 of the receiving terminal, is used for testing and alining receivers and combiners. Facilities are provided for applying the two carrier output signals from a given transmitter to the corresponding receivers. A balanced branching network is also provided in the DIVERSITY ALIGNMENT PANEL, which is used to connect the telegraph transmitter group to the telegraph receiver group for system tests.

## 141. General Theory of Power Distribution Circuits

The power equipment for each cabinet of the AN/FGC–29 terminal is shown in block form in figure 252. For a detailed discussion of the AN/FGC–29 terminal power circuits refer to paragraphs 210 through 222.

*a. Transmitting Terminal, Power Circuits.* Primary power at a nominal 115 or 230 volts (50 or 60 cps) enters the transmitting terminal at cabinet 1 and is applied to the power terminal box. The signal or station ground connection for the transmitting terminal also enters this cabinet and is applied to the equipment ground connection in the power terminal box. The main power unit accepts the primary power from the power terminal box and delivers both 115 and 230 volts ac. The 115-volt ac power from the main power unit enters the power terminal box where it is distributed to appropriate cabinet 1 circuits (LOOP BATTERY PANEL, TRANSMITTER METER PANEL, audiofrequency amplifiers, and multiplexers 1 and 2). The LOOP BATTERY PANEL contains fusing and switching facilities for the operation of rectifiers A and B. Rectifiers A and B accept 115 volts ac from the LOOP BATTERY PANEL and return −130 volts loop battery voltage. The loop battery voltages enter the LOOP BATTERY PANEL and are distributed to the transmitters in cabinet 2. The 115-volt ac power is also applied to the blower motor circuits in cabinets 1 and 2. The 230-volt ac power from the main power unit passes through the power terminal box in cabinet 1 to the power terminal box in cabinet 2. From there the 230-volt ac is applied through the AC POWER SWITCHING PANEL to the voltage regulator. The voltage regulator delivers a constant voltage of 230 volts ac through the AC POWER SWITCHING PANEL to the cabinet 2 power terminal box. The AC POWER SWITCHING PANEL permits the voltage regulator to be bypassed in case of failure so that cabinet 2 may continue to operate with unregulated power. From the power terminal box, the regulated 230 volts ac is applied to the appropriate cabinet 2 circuits (transmitters, SUBGROUP MODULATOR, and LEVEL CONTROL & PLATE SUPPLY). The LEVEL CONTROL & PLATE SUPPLY contains plate

supplies PS1 and PS2, which furnish +200 volts to transmitter channels 1 through 8, and 9 through 16, respectively.

*b. Receiving Terminal, Power Circuits.* Primary power at a nominal 115 or 230 volts (50 or 60 cps) is required to operate the receiving terminal and is applied to cabinet 3 and cabinet 5. The signal or station ground enters cabinet 3 and is applied to the equipment ground connection in the power terminal box. The primary power (at 115 or 230 volts ac), entering cabinet 3, passes through the power terminal box to the main power unit, which accepts either voltage and delivers both 115 and 230 volts ac. The 115 volts ac from the main power unit enters the power terminal box again where it is distributed to the appropriate cabinet 3 circuits (blower motor circuits, LOOP BATTERY PANEL, DIVERSITY ALIGNMENT PANEL, demultiplexers 1, 2, and 3, and audio-frequency amplifiers 1 and 2). The LOOP BATTERY PANEL contains fusing and switching facilities for operation at rectifiers A and B. Rectifiers A and B accept 115 volts ac from the LOOP BATTERY PANEL and deliver −130-volt loop battery voltage. The loop battery voltages enter the LOOP BATTERY PANEL for distribution to the combiners in cabinets 4, 5, and 6. The 115-volt ac power is also applied to the blower motor circuits in cabinet 4. The main power unit also supplies 230 volts ac through the power terminal box in cabinet 3 to the power terminal box in cabinet 4. From there, the 230-volt ac potential passes through the AC POWER SWITCHING PANEL to the voltage regulator. The voltage regulator delivers a constant voltage of 230 volts ac through the AC POWER SWITCHING PANEL to the power terminal box. The AC POWER SWITCHING PANEL permits operation of circuits in cabinets 4 and 5 on 230 volts ac unregulated power in case of failure of the voltage regulator. From the power terminal box, regulated 230 volts ac is applied to the receivers in cabinet 4. The regulated 230 volts ac also passes from the power terminal box in cabinet 4 to the power terminal box in cabinet 5 for components in cabinet 5 (RECEIVER CHANNEL 7, RECEIVER CHANNEL 8, and SUBGROUP DEMODULATOR A). The primary power entering cabinet 5 passes through the power terminal box to the main power unit which accepts either 115 or 230 volts ac and delivers both 115 and 230 volts ac. The 115-volt ac output of the main power unit is fed through the power terminal box to the blower motor circuits in cabinet 5 and cabinet 6. The step-up power transformer in cabinet 5 accepts 115 volts ac from the main power unit through the power terminal box and delivers 230 volts ac, which enters the power terminal box for distribution. One side of the step-up power transformer is grounded. Grounded 230 volts is applied to the combiners in cabinet 5 and, through the power terminal boxes in cabinets 4 and 6, for the appropriate circuits (combiners and RECEIVER METER PANEL) in these cabinets. The 230-volt ac power from the main power unit in cabinet 5 is fed through the cabinet 5 power terminal box to the power terminal box in cabinet 6. From there, the 230-volt ac power is applied through the AC POWER SWITCHING PANEL to the voltage regulator. The voltage regulator delivers a constant voltage of 230 volts ac through the AC POWER SWITCHING PANEL to the cabinet 6 power terminal box. The AC POWER SWITCHING PANEL permits operation of circuits in cabinets 5 and 6 on 230 volts ac unregulated power in case of failure of the voltage regulator. The regulated 230 volts ac is applied to the receivers in cabinet 6 and to the power terminal box for appropriate circuits in cabinet 5 (RECEIVER CHANNEL 9, RECEIVER CHANNEL 10, and SUBGROUP DEMODULATOR B).

## Section III. THEORY OF TRANSMITTER

### 142. Transmitter, General

The transmitter converts marking and spacing dc neutral telegraph signals into frequency-shift carrier signals. The carrier signals have a frequency deviation of ±42.5 cps from the center frequency of each channel. There are 16 telegraph channels in the AN/FGC–29 terminal divided into two groups of 8 channels each. One group contains the odd-numbered channels and the second group contains the even-numbered channels. The center frequencies of the channels in both groups are spaced 170 cycles apart and range from 1,785 to 2,975 cps. There are eight transmitters in the AN/FGC–29 terminal, each containing one even-numbered and one odd-numbered channel. A diversity switch in each transmitter permits opera-

tion of the two channels separately, with input signals from two transmitting telegraph loops, or together with input signals from a single telegraph loop. The first mode of operation is called two-channel diversity and the second is called four-channel diversity. TRANSMITTER CHANNELS 1 & 2 is discussed as a typical example. The remaining transmitters operate identically, except that the carrier signal frequencies (par. 7*c*) are different.

## 143. Transmitter, Block Diagram Analysis

Figure 77 is a block diagram of the transmitter, with channel 1 shown at the top of the figure and channel 2 at the bottom. For a detailed analysis of the transmitter circuits, refer to paragraphs 144 through 154 and the schematic diagram (fig. 78).

*a. Channel 1.* Telegraph signals from telegraph loop 1 are applied to channel 1 of the transmitter through LOOP CURRENT ADJUST control R21. This control is a variable resistor which adjusts the dc in the loop circuit. The signals next pass through LOOP CURRENT SELECTOR switch S2, which permits operation of the channel with either 60- or 20-ma loop current. From there, the signals are applied to the oscillator keying circuit, which operates in conjunction with oscillator VIB to produce frequency-shift marking and spacing signals. The oscillator keying circuit and oscillator VIB circuit are physically located partly in keyer Y1, and partly in oscillator tuner Z1. For the details of keyer and oscillator tuner circuits, refer to the schematic diagrams of these units (figs. 81 and 82). The oscillator keying circuit is arranged for different operating conditions by LOOP TERMINATION switch S1 and DIVERSITY switch S5. The LOOP TERMINATION switch arranges the channel for correct operation when the distant end of the sending loop is terminated in negative battery, positive battery, or ground, and also opens its associated circuit for testing. DIVERSITY switch S5, connected between channel 1 and channel 2, is used in two-channel diversity to connect loop 1 and loop 2 to channels 1 and 2, respectively. The resonant frequency of the oscillator keying circuit is varied by the marking and spacing loop signals and controls the frequency of oscillator VIB. A marking signal increases the frequency of oscillator VIB to 42.5 cps above the channel center frequency and a spacing signal decreases the frequency 42.5 cps below the channel center frequency. The frequency-shift signals from the oscillator are fed to buffer amplifier VIA, which isolates the oscillator from transmitter filter FL1. The signals from the buffer amplifier arrive at IDLE-NORMAL switch S3, which either applies them to transmitter filter FL1 when in the NORMAL position, or shorts them to ground in the IDLE position. Transmitter band-pass filter FL1 restricts the buffer amplifier output to the assigned frequency band for channel 1. The output signals from transmitter filter FL1 in channel 1 join the output signals of the other seven odd-numbered channels at the odd channel send bus and together pass to the SUBGROUP MODULATOR.

*b. Channel 2.* Telegraph signals from loop 2 are applied to channel 2 of the transmitter through LOOP CURRENT ADJUST control R22. This control is a variable resistor, which adjusts the dc in the loop circuit. The signals next pass through LOOP CURRENT SELECTOR switch S2, which permits operation of the channel with either 60- or 20-ma loop current. From there the signals are applied to the oscillator keying circuit, which operates in conjunction with oscillator VIB to produce frequency-shift marking and spacing signals. The oscillator keying circuit and oscillator VIB circuit are located partly in keyer Y2 and partly in oscillator tuner Z2. For details of the keyer and oscillator tuner circuits, refer to the schematic diagrams of these units (figs. 81 and 82). The oscillator keying circuit is arranged for different operating conditions by LOOP TERMINATION switch S1 and DIVERSITY switch S5. Switch S1 arranges the oscillator keying circuit for correct operation when the distant end of the sending loop is terminated in negative battery, positive battery, or ground, and also opens its associated circuits for testing. DIVERSITY switch S5, connected between channel 1 and channel 2, is used in two-channel diversity to connect loops 1 and 2 to channels 1 and 2, respectively. The resonant frequency of the oscillator keying circuit is varied by the marking and spacing loop signals and controls the frequency of oscillator VIB. A marking signal increases the frequency of oscillator VIB to 42.5 cps above the channel center frequency and a spacing signal decreases the frequency 42.5 cps below the channel center frequency. The frequency-shift signals from the oscillator are fed to buffer amplifier VIA, which isolates the oscillator from transmitter filter FL2. The signals from the buffer amplifier arrive at IDLE-NORMAL switch S4, which either applies them to transmitter filter FL2 when in the

NORMAL position, or shorts them to ground in the IDLE position. Transmitter filter FL2 is a band-pass filter which restricts the buffer amplifier output to the assigned frequency band for channel 2. The output signals from transmitter filter FL2 in channel 2 join the output signals of the other seven even-numbered channels at the even channel send bus and together pass to the SUBGROUP MODULATOR.

*c. Four-Channel Diversity.* DIVERSITY switch S5 is used in four-channel diversity to permit signals from loop 1 to key the oscillators of channels 1 and 2 and leave loop 2 unterminated. This is accomplished by opening the circuit from loop 2 and connecting the oscillator keying circuit of channel 2 in series with the oscillator keying circuit of channel 1. The signals from loop 1 pass through both oscillator keying circuits and control the frequency of channel 1 and channel 2 oscillators VIB. DIVERSITY switch S5 can be operated manually at the transmitters or electrically from a remote control station. Signals from the remote control station control a rotary solenoid switch actuator (part of switch S5) to arrange the transmitter for two-channel or four-channel diversity operation.

*d. Power Distribution Circuits.* Two identical bias supplies PS1 and PS2 furnish ungrounded 35 volts dc for the oscillator keying circuits of channels 1 and 2, respectively, and 6.3 volts ac for the heaters of oscillator V1B and buffer amplifier VIA in keyers Y1 and Y2. The bias supplies are operated from regulated 230 volts ac at 50 or 60 cps. B-plus at 200 volts dc for tubes V1A and V1B in both keyers is supplied from the LEVEL CONTROL & PLATE SUPPLY (par. 169). Loop battery of −130 volts dc is applied to switch S1 in keyer Y1 and switch S1 in keyer Y2 to furnish current for the transmitting telegraph loops when the loops are terminated in ground. The loop battery applied to keyer Y2 is also applied to the DIVERSITY switch actuator to permit remote operation of DIVERSITY switch S5.

*Figure 77. Transmitter, block diagram.*
(Contained in separate envelope)

## 144. Transmitter, Schematic Diagram Analysis

The signal paths of the transmitter are shown in detail on the schematic diagram (fig. 254) with the switches arranged for two-channel diversity operation, 60-ma loop current, and grounded loop termination. In the following discussion circuits which are identical in both channels are discussed with reference to channel 1. When reference symbols for channel 2 differ from channel 1 they are given in parentheses following those for channel 1.

## 145. Transmitter Input Circuits, Schematic Diagram Analysis

(fig. 254)

The dc telegraph signals applied to the transmitter consist of marking (closed loop) and spacing (open loop) impulses. The dc telegraph signals from loop 1 (loop 2) enter channel 1 (2) at terminal A (B) of connector J16 and pass through fuse F1 (F5) bridged by BLOWN FUSE INDICATOR I 1 (I 5) to LOOP jack J9 (J12). The signals then pass through EQUIP jack J10 (J13) and LOOP CURRENT ADJUST resistor R21 (R22) to terminal 11 on terminal board TB3 of keyer Y1 (Y2) where they enter the switching circuits.

## 146. Transmitter Switching Circuits, Schematic Diagram Analysis

(figs. 79 and 254)

The switching circuits include LOOP CURRENT SELECTOR switch S2, LOOP TERMINATION switch S1, and DIVERSITY switch S5. These switches are used in combination and are discussed for various operating arrangements of the transmitter. Figure 79 is a simplified schematic diagram of the switching circuits arranged for operation of the transmitter in two-channel diversity with grounded loop termination and 60-ma loop current. This figure is discussed in *a* below.

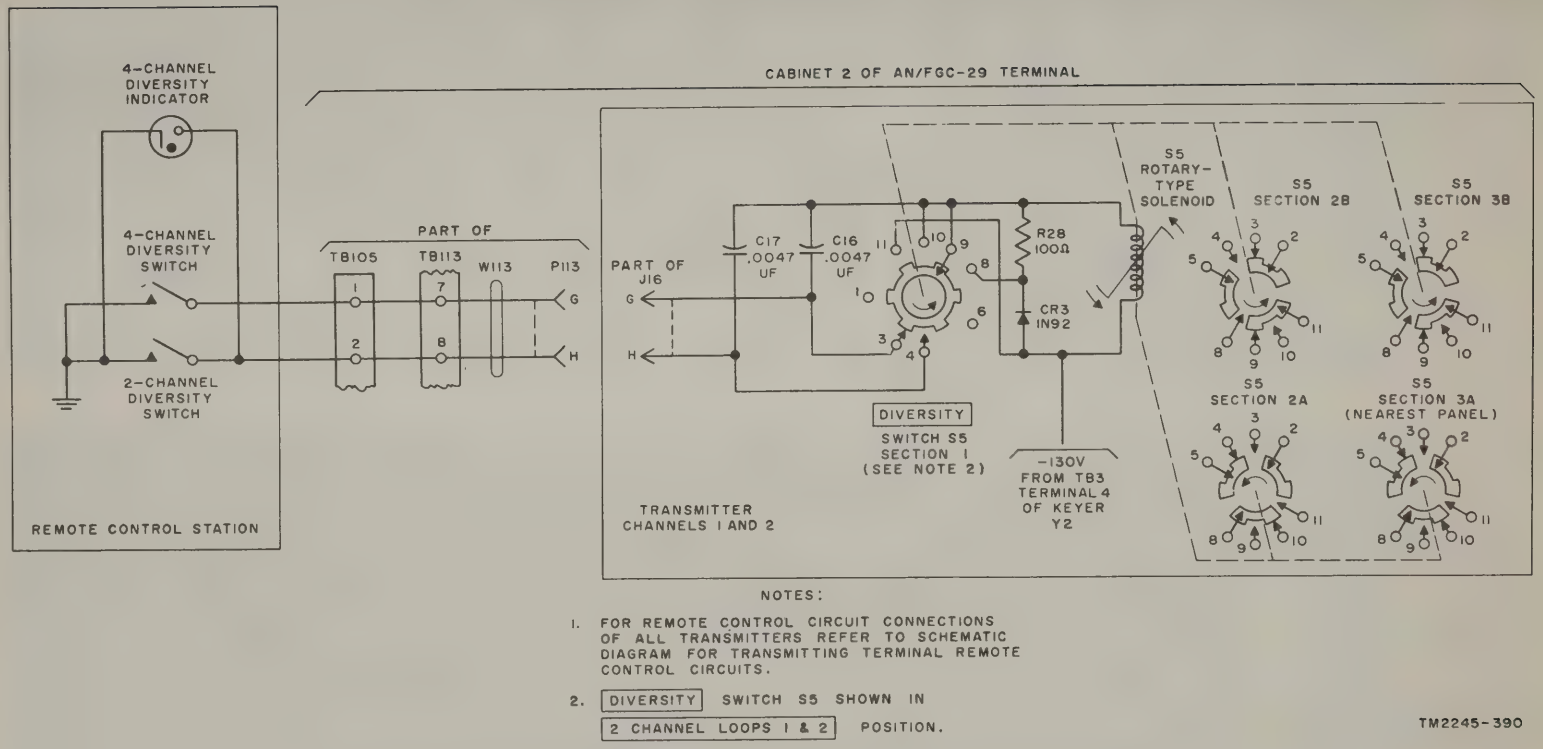
*a.* The dc telegraph loop signals enter the switching circuits at terminal 11 on terminal board TB3 of keyer Y1 (Y2) and are routed by way of switch terminals 6 and 5 on section 2 of LOOP TERMINATION switch S1 through terminal 10 of terminal board TB3 to normally closed MONITOR jack J11 (J14). The signals return from the jack through terminal 9 of terminal board TB3 to terminal 9 of section 2, switch S1 and pass to terminal 10. From terminal 10 of switch S1 the signals are routed through terminals 6 and 5 of LOOP CURRENT SELECTOR switch S2, thereby bypassing resistor R11, and continue to terminals 2 and 5 of DIVERSITY switch S5, section 3 (2), by way of terminal 7 on terminal board TB3. The signals leave switch S5 at terminal 3, section 3 (2), and pass through terminal 6 of terminal board TB3, re-entering switch S2 at terminal 9. The signals bypass resistor R26 via terminals 9 and 8 of switch S2, and pass

through resistor R12 to the common junction of resistors R10 and R25. Part of the loop current flows through resistor R25 and enters the frequency-shift circuit (par. 147) at resistor R9, by way of terminals 5 and 6 of section 1, switch S1. The remainder of the loop current bypasses resistor R10 through terminals 2 and 3 of switch S2 and flows through resistor R13 to terminal 3 on terminal board TB3. When loop current flows in the frequency-shift circuit, a marking carrier frequency is transmitted from the channel. When the loop current is interrupted by a spacing loop signal, spacing carrier frequency is transmitted. Loop current leaving the frequency-shift circuit from resistors R23 and R24 passes through terminals 2 and 1 of section 1, switch S1, and rejoins the loop current from resistor R13 at terminal 3 on terminal board TB3. In channel 1, terminal 3 is strapped to terminal 5 and the loop current returns to —130-volt loop battery by way of terminals 1 and 2 of section 2, switch S1, terminal 4 of terminal board TB3, and terminal C of connector J16. In channel 2, terminal 3 on terminal board TB3 is connected to terminal 5 by way of terminal 8 or 11 and terminal 10 of section 2A of switch S5. The loop current returns to —130 volts through terminal 4 of terminal board TB3 and terminal D of connector J16.

*b.* To operate the channel with 20-ma loop current, LOOP CURRENT SELECTOR switch S2 (fig. 79) is placed in the 20MA position. This action short circuits resistors R12 and R25, and inserts resistors R11, R26, and R10. Resistors R11 and R26 reduce the loop current from 60 ma to 20 ma. The current divides at the junction of resistors R25 and R10, part flowing through contacts 2 and 1 of switch S2 and the frequency-shift circuit, and part flowing through resistors R10 and R13, which parallel this circuit. Resistor R10 maintains the same current flow through the frequency-shift circuit for operation with 20 ma as for operation with 60-ma loop current. The operation of the frequency-shift circuit, therefore, is identical for both 60-ma or 20-ma loop currents.

*c.* LOOP TERMINATION switch S1 (fig. 79) makes it possible to operate the telegraph transmitting loop with its distant end terminated in positive or negative battery. When the distant end of the loop is terminated in positive battery, switch S1 is placed in the POS position. The circuit is unaltered except that the loop current from terminal 5 of terminal board TB3 returns to ground through contacts 1 and 3 of section 2 of switch S1 instead of to —130 volts dc. Connections to MONITOR jack J11 (J14) are made through terminals 7 and 5 and terminals 9 and 11 of section 2 of switch S1. Connections to the frequency-shift circuit are made through terminals 5 and 7 and terminals 3 and 1 on section 1 of switch S1. When the distant end of the loop is terminated in negative battery, switch S1 is placed in the NEG position. In this case, the direction of loop current flow reverses so that the connections to MONITOR jack J11 (J14) and to the frequency-shift circuit must also be reversed to maintain the proper direction of current flow through these circuit elements. Connections to jack J11 (J14) are reversed by terminals 12 and 9 and terminals 5 and 8 on section 2 of switch S1. Connections to the frequency-shift circuit are reversed by terminals 5 and 8 and terminals 4 and 1 on section 1 of switch S1. The loop current from terminal 5 of terminal board TB3 returns to ground through contacts 1 and 4 on section 2 of switch S1. In the OPEN position of LOOP TERMINATION switch S1 all circuits through the switch are opened. This position is used only when shooting trouble in the transmitter channel.

*d.* DIVERSITY switch S5 in the 4 CHANNEL LOOP 1 ONLY position (fig. 79) makes it possible to key both channels with the telegraph signals of loop 1. The loop 1 signals are transmitted on the carrier frequency of channel 2, as well as the carrier frequency of channel 1. In this arrangement, the connection between terminal 3 and terminals 2 or 5 of switch S5, section 2B, is opened, thereby opening the circuit between terminals 7 and 6 of terminal board TB3 of channel 2, keyer Y2. As a result loop 2 is opened. The loop 1 current from terminal 7 on terminal board TB3 of channel 1 passes through terminal 5 or 2 and terminal 4 of section 3B of switch S5, to terminal 8 on terminal board TB3 of channel 2. From terminal 8 the loop 1 current is applied to the junction of resistors R10 and R25. Here the current divides, part flowing through the channel 2 frequency-shift circuit and the remainder through resistor R13. The currents rejoin at terminal 3 of terminal board TB3 and pass through terminal 8 or 11 and terminal 9 of switch S5, section 2B, to terminal 8 on terminal board TB3 of channel 1. From terminal 8, the loop current is applied to the junction of resistors R10 and R25. Here the current again divides, part flowing through the channel 1 frequency-shift circuit and the remainder through resistor R13. The currents rejoin at




NOTES:

1. FOR REMOTE CONTROL CIRCUIT CONNECTIONS OF ALL TRANSMITTERS REFER TO SCHEMATIC DIAGRAM FOR TRANSMITTING TERMINAL REMOTE CONTROL CIRCUITS.
2. DIVERSITY SWITCH S5 SHOWN IN 2 CHANNEL LOOPS 1 & 2 POSITION.

TM2245-390

*Figure 78. Transmitter, DIVERSITY switch S5, remote switching, schematic diagram.*

terminal 3 of terminal board TB3 and return to −130-volt loop battery. This circuit arrangement permits the telegraph signals from loop 1 to key the frequency-shift circuits of both channels 1 and 2. When operating the transmitter in four-channel diversity, the LOOP TERMINATION switch S1 and LOOP CURRENT SELECTOR switch S2 of both channels must be set in the same positions.

*e.* DIVERSITY switch S5 can be operated manually at the transmitter, or electrically from a remote control station. Figure 78 shows the switch actuator part of DIVERSITY switch S5 in TRANSMITTER CHANNELS 1 & 2 with control circuits extended to a typical remote control station. For details of the remote control circuits for the remaining transmitters in the transmitting terminal, refer to paragraph 208. The rotary solenoid is mounted at one end of switch S5 and is coupled to the rotary shaft of the switch through a ratchet mechanism. Each time the solenoid operates, the switch is stepped one position counterclockwise (viewed from the panel end of the switch). Alternate positions of the switch arrange the transmitter for two-channel or four-channel diversity operation. The particular position of the switch is indicated by the manual operating knob and front-panel marking. When in the 2 CHANNEL LOOPS 1 & 2 position, a control circuit is established from −130 volts on terminal 4 of terminal board TB3 of keyer Y2 through the solenoid winding, and contacts 9 and 3 of switch S5, section 1, to terminal G of connector J16 of the transmitter. From there the circuit continues through the mating terminal of plug P113 and cable W113 to terminal 7 of terminal board TB113 which connects to terminal 1 of terminal board TB105. At this point the circuit leaves the AN/FGC–29 terminal and is extended to the four-channel diversity (nonlocking) type switch at the remote location. When this switch is closed to ground, current flows in the control circuit energizing the solenoid which steps the switch to the next position (4 CHANNEL LOOP 1 ONLY). This action opens the connection between terminals 3 and 9 of switch section 1 and closes terminals 4 and 9 thereby transferring the solenoid connection from the four-channel diversity switch at the remote control station to the two-channel diversity (nonlocking type) switch. Connection to the two-channel diversity switch is established from terminal 4 of switch section 1 through terminal H of connector J16 and plug P113, cable W113, terminal 8 of terminal board TB113, and terminal 2 of terminal board TB105. When this switch is closed to ground, the solenoid is again energized advancing the DIVERSITY switch one position (2 CHANNEL LOOPS 1 & 2 position), and transferring control back to the four-channel diversity switch in the remote control station. When switch S5 is in the 4 CHANNEL LOOP 1 ONLY position, the −130-volt battery potential appears across the two-channel diversity switch which is always open except when being operated. As a result, the four-channel neon INDICATOR lamp bridged across the two-channel diversity switch, glows indicating that the transmitter is arranged for four-channel diversity operation. Spark suppression for the solenoid control circuit is furnished by diode CR3 in series with resistor R28 connected across the solenoid winding and capacitors C16 and C17 bridged across terminals 3 and 9 and terminals 4 and 9, respectively, of switch section 1.

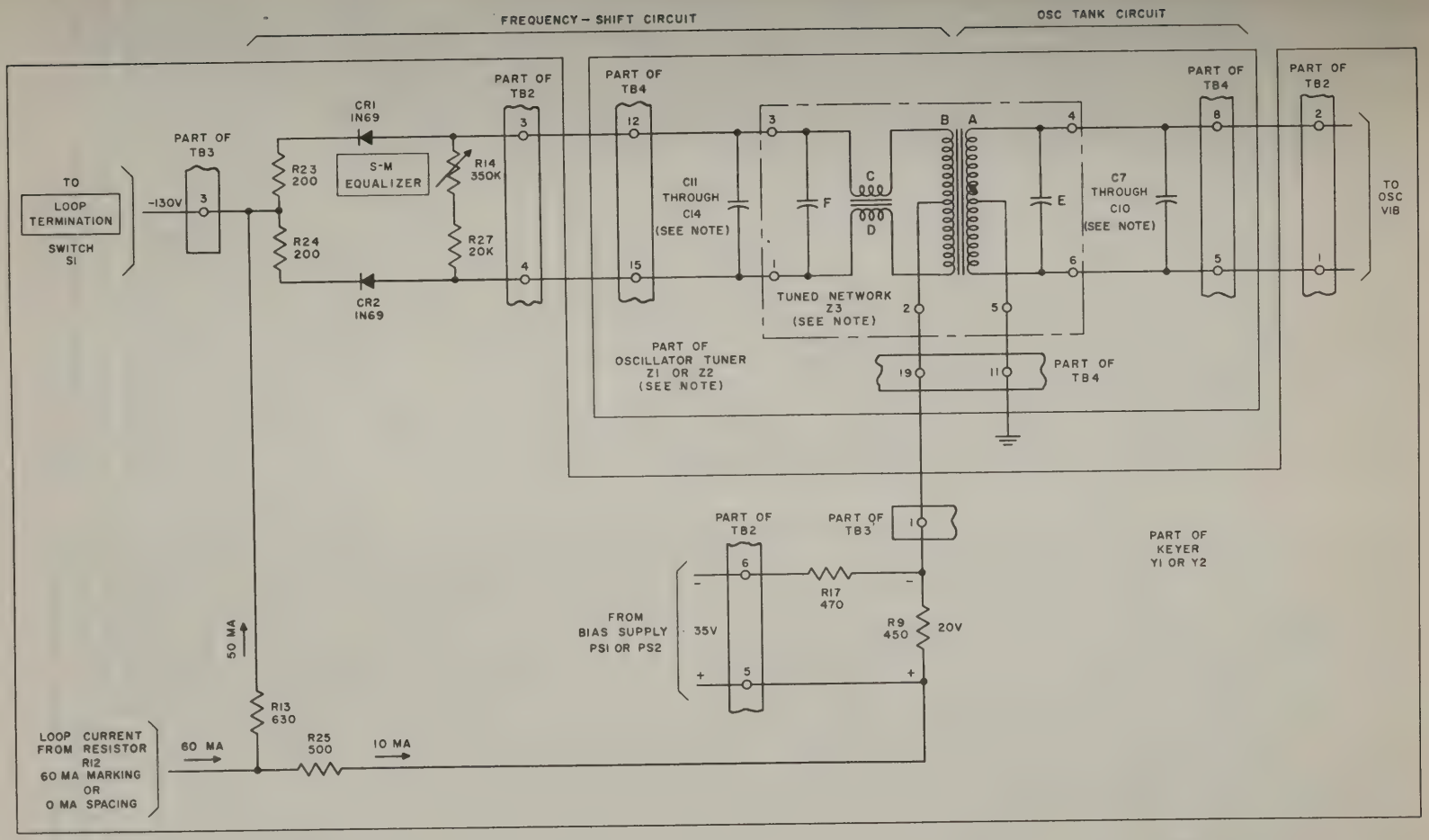
*Figure 79. Transmitter, switching circuits, simplified schematic diagram.*

(Contained in separate envelope)

## 147. Transmitter, Oscillator Keying Circuit, Schematic Diagram Analysis

(figs. 80 and 254)

The dc telegraph signals from terminal 11 on terminal board TB3 pass through the switching circuits (par. 146) to the oscillator keying circuit (fig. 80), which consists of a frequency-shift circuit and an oscillator tank circuit. The oscillator keying circuit is located partly in keyer Y1 (Y2) and partly in oscillator tuner Z1 (Z2). Circuit details of keyer Y1 (Y2) are shown in figure 81 and of oscillator tuner Z1 (Z2) in figure 82. All switch segments associated with these circuits have been omitted from figure 80 to simplify the circuit discussion. Transformer winding A of tuned network Z3 and its associated tuning capacitor E and trimmer capacitors C7 through C10 form the main tank circuit of oscillator V1B. Transformer winding A is inductively coupled to winding B so that any change in the reactance connected to winding B is transferred to the main tank circuit and effects the frequency of oscillator V1B. Marking and spacing loop signals flowing through the frequency-shift circuit appropriately alter the reactance associated with winding B to cause oscillator V1B




NOTE:

FOR VALUES OF CAPACITORS C7 THROUGH C14 AND FREQUENCY DESIGNATIONS OF TUNED NETWORK AND OSCILLATOR TUNER, SEE SCHEMATIC DIAGRAM OF TRANSMITTER.

TM2245-359

*Figure 80. Transmitter, oscillator keying circuit, simplified schematic diagram.*

to generate marking and spacing frequencies. The operation of the circuit for marking signal is given in *a* below and for spacing signal in *b* below. For both discussions, 60-ma marking loop current is assumed. Operation with either 20-ma or 60-ma loop current is the same except for the circuit changes described in paragraph 146.

*a. Marking Signal.* The oscillator tank circuit, at terminals 4 and 6 of tuned network Z3, and associated trimmer capacitors C7 through C10 are connected to oscillator V1B through terminals 5 and 8 on terminal board TB4 of oscillator tuner Z1 (Z2), and terminals 1 and 2 on terminal board TB2 of keyer Y1 (Y2). The center tap of the tank circuit from terminals 5 of tuned network Z3 is grounded through terminal 11 on terminal board TB4 of oscillator tuner Z1 (Z2). A 60-ma marking telegraph loop signal from resistor R12 in keyer Y1 (Y2) causes approximately 10 ma to flow through resistor R25 and the frequency-shift circuit to —130-volt loop battery at terminal 3 of terminal board TB3. The remaining loop current bypasses the frequency-shift circuit through resistor R13 to —130-volt loop battery at terminal 3 on terminal board TB3. Current from resistor R25 in keyer Y1 (Y2) flows through resistor R9 to the center tap of transformer winding B through terminal 1 on terminal board TB3 of keyer Y1 (Y2), terminal 19 on terminal board TB4 of oscillator tuner Z1 (Z2), and terminal 2 on tuned network Z3. At this point, the current divides equally. One-half of the current flows through the upper portion of winding B, then through winding C of a balanced transformer, to terminal 3 of tuned network Z3. The other half of the current flows through the lower portion of winding B, then through winding D of the balanced transformer, to terminal 1 of tuned network Z3. These currents are balanced with respect to the main tank circuit winding A to minimize disturbance to oscillator V1B from the dc loop signals. The current paths continue separately through terminals 12 and 15 on terminal board TB4 of oscillator tuner Z1 (Z2) and terminals 3 and 4 on terminal board TB2 of keyer Y1 (Y2) and recombine after passing through diodes CR1 and CR2 and resistors R23 and R24. The currents flow through diodes CR1 and CR2 in the conducting direction and reduce their impedances to a low value, thereby effectively shunting terminals 3 and 1 of tuned network Z3 with low valued resistors R23 and R24 in series. As a result, capacitor F, trimmer capacitors C11 through C14, and series resistors R14 and R27 are short-circuited so that the reactance connected to winding B is essentially the series reactance of winding C and D of the balanced transformer. This inductive reactance is electrically in parallel with the oscillator tank circuit due to the magnetic coupling between windings A and B and increases its resonant frequency so that oscillator V1B generates the marking frequency.

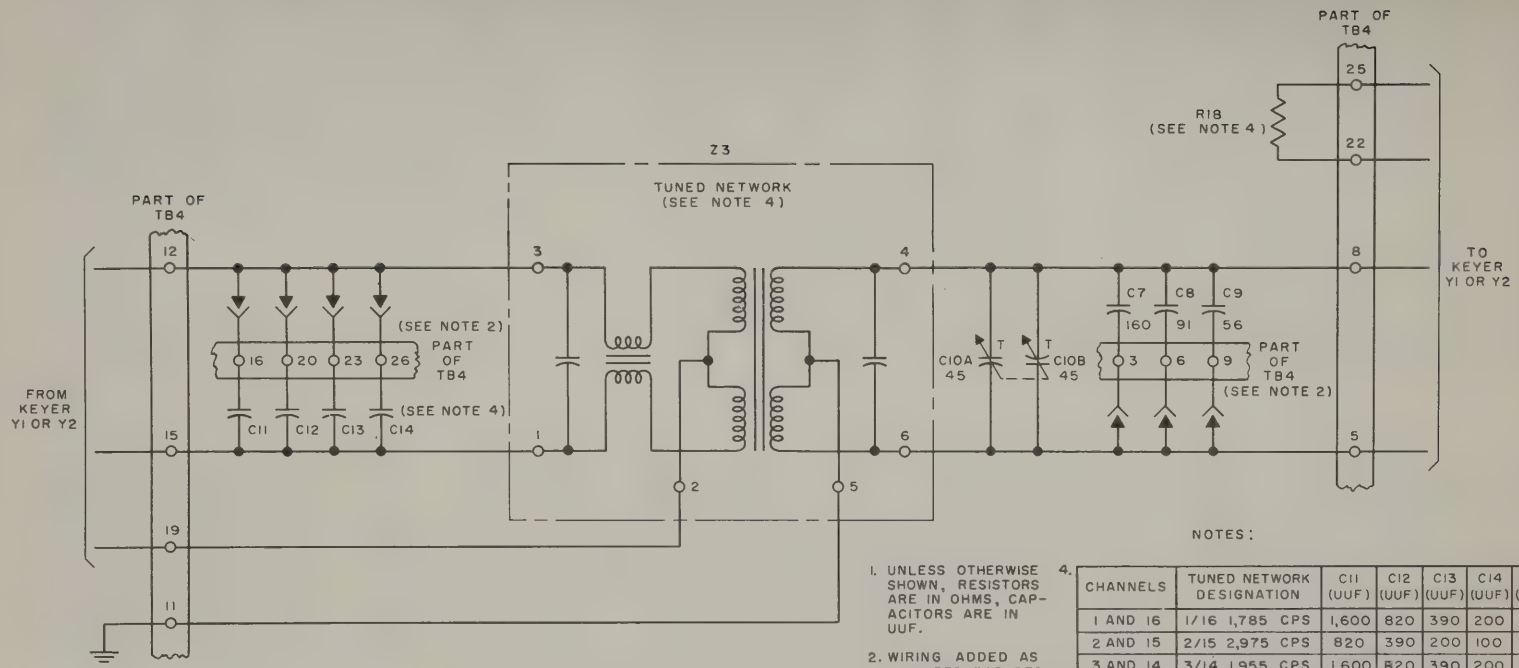
*b. Spacing Signal.* A spacing telegraph signal opens the loop circuit and interrupts the flow of loop current through the frequency-shift circuit. Of the 35-volt potential from bias supply PS1 (PS2), applied to terminals 5 and 6 on terminal board TB2 of keyer Y1 (Y2) and impressed across resistors R9 and R17 in series, approximately 20 volts appear across resistor R9. The potential across resistor R9 is of the proper polarity to bias diodes CR1 and CR2 in the nonconducting direction, and effectively isolates resistors R23 and R24 from terminals 3 and 1 of tuned network Z3. Under this condition, capacitor F, trimmer capacitors C11 through C14, and resistors R14 and R27, which were shorted out by the marking signal, are now in series with windings C and D of the balanced transformer. The capacitors change the reactance connected to winding B from inductive reactance to capacitive reactance. This capactive reactance is electrically in parallel with the oscillator tank circuit and lowers its resonant frequency so that oscillator V1B generates the spacing frequency. Variable resistor R14, in series with resistor R27, varies the level of the spacing frequency signal and is adjusted to match the levels of the marking and spacing frequency signals.

*Figure 81. Transmitter, keyer, schematic diagram.*
(Contained in separate envelope)

## 148. Transmitter, Oscillator and Buffer Amplifier Circuits, Schematic Diagram Analysis

(figs. 83 and 254)

Figure 84 is a simplified schematic diagram of the oscillator and buffer amplifier circuit. Transformer winding A and associated tuning capacitor E and trimmer capacitors C7 through C10 in oscillator tuner Z1 (Z2) form the main tank circuit for oscillator V1B in keyer Y1 (Y2). The resonant frequency of the tank circuit is controlled by the dc telegraph loop signals (par. 147). Oscillation begins in tube V1B with amplification of




NOTES:

1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UUF.
2. WIRING ADDED AS REQUIRED FOR RESONANCE.
3. FOR EXTERNAL CONNECTIONS SEE SCHEMATIC DIAGRAM OF TRANSMITTER.
4.

| CHANNELS | TUNED NETWORK DESIGNATION | C11 (UUF) | C12 (UUF) | C13 (UUF) | C14 (UUF) | R18 (OHMS) |
|---|---|---|---|---|---|---|
| 1 AND 16 | 1/16 1,785 CPS | 1,600 | 820 | 390 | 200 | 30K |
| 2 AND 15 | 2/15 2,975 CPS | 820 | 390 | 200 | 100 | 39K |
| 3 AND 14 | 3/14 1,955 CPS | 1,600 | 820 | 390 | 200 | 39K |
| 4 AND 13 | 4/13 2,805 CPS | 820 | 390 | 200 | 100 | 30K |
| 5 AND 12 | 5/12 2,125 CPS | 1,600 | 820 | 390 | 200 | 20K |
| 6 AND 11 | 6/11 2,635 CPS | 820 | 390 | 200 | 100 | 20K |
| 7 AND 10 | 7/10 2,295 CPS | 1,600 | 820 | 390 | 200 | 30K |
| 8 AND 9 | 8/9 2,465 CPS | 1,600 | 820 | 390 | 200 | 39K |

TM2245-336

*Figure 82. Transmitter, oscillator tuner, schematic diagram.*

noise on the grid. The amplified noise appearing across plate load resistor R8 passes through capacitor C2 and feedback resistor R5 to terminal 2 of terminal board TB2. From there, the noise is applied to the tank circuit through terminal 8 of terminal board TB4 of oscillator tuner Z1 (Z2). The tank circuit is responsive only to its resonant frequency and this particular component of the noise is fed back to the grid of oscillator V1B from terminal 5 on terminal board TB4 of oscillator tuner Z1 (Z2) through terminal 1 on terminal board TB2 of keyer Y1 (Y2) and grid isolating resistor R7. Continued amplification produces sustained oscillations at the resonant frequency of the tank circuit. The level of oscillation is controlled by plate dropping resistor R18, bypassed to ground by capacitor C3. Resistor R18, located in oscillator tuner Z1 (Z2), is connected between terminals 22 and 25 of terminal board TB4. Plate voltage, applied at terminal 14 on terminal board TB3 of keyer Y1 (Y2), passes through terminal 14 on terminal board TB2 and terminal 25 on terminal board TB4 of oscillator tuner Z1 (Z2) to resistor R18. The plate voltage from resistor R18 leaves at terminal 22 of terminal board TB4 and is applied to plate load resistor R8 and bypass capacitor C3 in keyer Y1 (Y2) by way of terminal 9 of terminal board TB2. Cathode bias for the oscillator is provided by resistor R2. The output of oscillator V1B is taken from the tank circuit side of grid isolating resistor R7 and fed through output isolating resistor R6, blocking capacitor C1, and CARRIER LEVEL resistor R15 to ground. The carrier signal from the variable tap of resistor R15 is applied to the grid of buffer amplifier V1A, a cathode follower stage. Resistors R3 and R1 match the output impedance of the cathode follower to the 7,500 ohm input impedance of transmitter filter FL1 (FL2) which follows.

## 149. Transmitter Output Circuits, Schematic Diagram Analysis

(fig. 254)

The output of buffer amplifier V1A is applied to the output circuits of the transmitter. Signals appearing at the cathode of buffer amplifier V1A pass through resistors R3 and R1 to input terminal 3 of transmitter filter FL1 (FL2) by way of terminal 13 on terminal board TB3. Output signals from terminal 1 of transmitter filter FL1 (FL2) pass through CHANNEL OUTPUT jack J1 (J5) and leave the transmitter by way of terminal J (K) on connector J16. Terminals 2 and 4 of transmitter filter FL1 (FL2) and CHANNEL OUTPUT jack J2 (J6) form the grounded side of the output circuit. The carrier signals present across resistor R1 are used for monitoring the output of buffer amplifier V1A and are impressed on CARRIER MONITOR jacks J3 (J7) and J4 (J8) through terminals 12 and 2, respectively, on terminal board TB3. Carrier transmission from the channel ceases when IDLE-NORMAL switch S3 (S4) is set in the IDLE position. This is accomplished by grounding input terminal 3 on transmitter filter FL1 (FL2) through terminals 2 and 13 on terminal board TB3 of keyer Y1 (Y2). The IDLE-NORMAL switch simultaneously applies 6.3 ac to illuminate loop IDLE INDICATOR lamp I 6 (I 7).

*Figure 83. Transmitter, oscillator and buffer amplifier circuits, simplified schematic diagram.*

(Contained in separate envelope)

## 150. Transmitter Power Supply Circuits, Schematic Diagram Analysis

(fig. 254)

The 230 volts ac regulated power at 50 or 60 cps is brought to the transmitter at connector J15 and applied through fuses F3 and F4 to terminals 1 and 4 of input transformer T2 in bias supply PS1 (PS2). Fuses F3 and F4 are inserted in each side of the power line to protect the transmitter against overload. BLOWN FUSE INDICATOR lamps I 3 and I 4 are bridged across fuses F3 and F4. If either fuse blows, the input voltage is applied across the corresponding neon indicator lamp, causing it to glow. The 6.3 volts ac output of bias supply PS1 (PS2) on terminals 1 and 2 of terminal board TB5 supplies tube heater voltage to keyer Y1 (Y2) at terminals 7 and 8 of terminal board TB2 and also to loop IDLE INDICATOR I 6 (I 7). The 35-volt dc bias voltage at terminals 3 and 4 on terminal board TB5 of bias supply PS1 (PS2) is applied to terminals 5 and 6 of terminal board TB2 on keyer Y1 (Y2). The +200-volt dc plate voltage from the LEVEL CONTROL & PLATE SUPPLY for oscillator V1B and buffer amplifier V1A in keyer Y1 (Y2) enters the transmitter at terminal F on connector J16 and is applied through fuse F2 to terminal 14 on terminal board TB3 of keyer Y1 (Y2). BLOWN FUSE INDICATOR I 2 is bridged across fuse F2 and glows when the fuse is blown. The −130-volt dc loop battery from the LOOP BATTERY PANEL is brought

in at terminal C (D) of connector J16 and applied to terminal 4 on terminal board TB3 of keyer Y1 (Y2).

## 151. Transmitter, Theory of Jacks and Controls
(fig. 254)

Two groups of telegraph jacks marked LOOP 1 or LOOP 2 provide connection to the dc circuit of the transmitter for measuring, patching, and monitoring the loop signals. In each group there is a LOOP jack, and EQUIP jack, and a MONITOR jack used with cords equipped with single plugs. The LOOP jack is used for testing the telegraph loop or for patching the loop to an EQUIP jack of another channel. The EQUIP jack is used for transmitting local test signals over the channel or for patching the channel to the LOOP jack of a different channel. The MONITOR jack is used for adjusting the loop current in conjunction with the associated LOOP CURRENT ADJUST control, or for checking bias on incoming telegraph signals from the loop. Two groups of carrier jacks are provided on each channel of the transmitter for monitoring and measuring the carrier output signals. In each group there are a pair of CHANNEL OUTPUT jacks and a pair of CARRIER MONITOR jacks used with cords equipped with twin plugs. The CARRIER OUTPUT jacks permit measurement of the level of the output signals of the channel. The CARRIER MONITOR jacks permit the output of buffer amplifier V1A to be checked.

## 152. Transmitter, Theory of Bias Supply
(fig. 84)

The bias supply is a conventional full-wave rectifier circuit which accepts a 230-volt ac regulated input at 50 or 60 cps. and delivers 35 volts dc for use in the oscillator keying circuit, and 6.3 volts ac for vacuum tube heater circuits. The ac input is applied to primary terminals 1 and 4 of transformer T2 with terminals 2 and 3 strapped. The voltage developed between secondary terminals 7 and 9 is applied to the plates of rectifier V3. In the positive half-cycle of the applied voltage, one plate conducts, and in the negative half-cycle, the second plate conducts. A pulsating dc voltage is developed between the common cathode of rectifier V3 and center tap terminal 8 of the transformer secondary. The dc output is applied through a filter, consisting of series inductor L1 and shunt capacitor C15, to terminals 3 and 4 of terminal board TB5. Resistor R20 is the load resistor. Heater voltage at 6.3 volts ac is taken from terminals 5 and 6 on a separate winding of transformer T2 for the heater of rectifier V3, and is also applied to terminals 1 and 2 on terminal board TB5.

## 153. Transmitter, Theory of Tuned Network
(fig. 85)

Tuned network Z3 in oscillator tuner Z1 or Z2 is a hermetically sealed unit containing the frequency determining elements for oscillator V1B. Terminals 1, 2, and 3 connect the frequency-

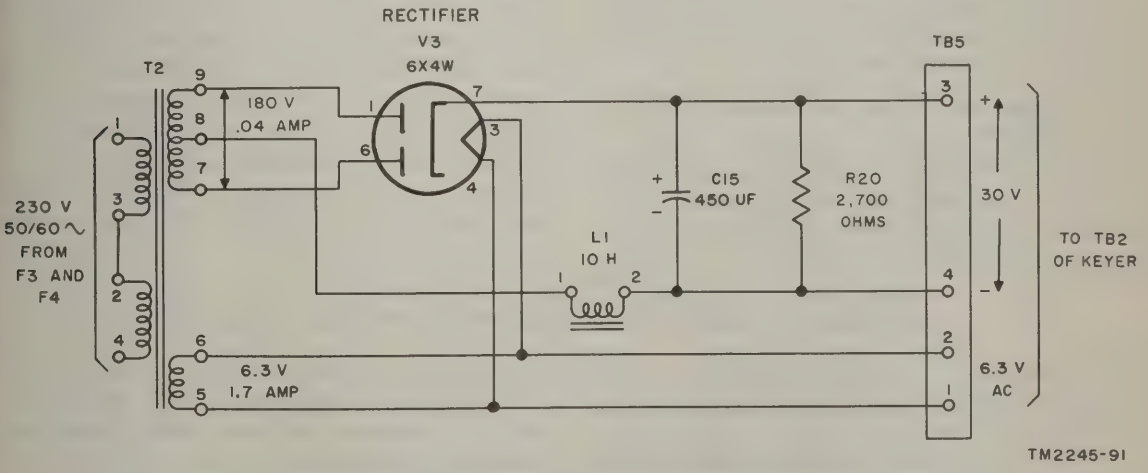



*Figure 84. Transmitter, bias supply, schematic diagram.*

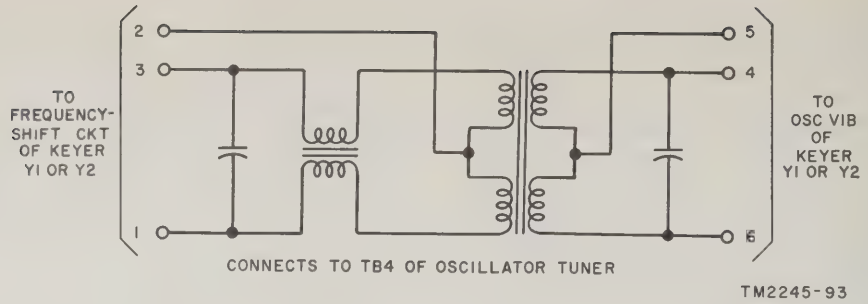



*Figure 85. Transmitter, tuned network, schematic diagram.*

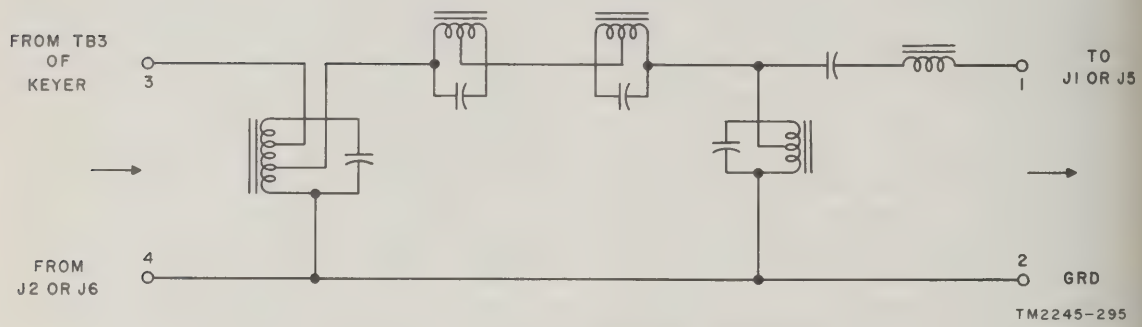



*Figure 86. Transmitter filter, schematic diagram.*

shift part of the tuned network to the frequency-shift part of keyer Y1 or Y2. Terminals 4, 5, and 6 connect the oscillator tank part of the tuned network to the oscillator V1B circuit of keyer Y1 or Y2. These elements determine the marking and spacing frequencies for a particular channel. The channel and frequency designations of the tuned networks are given on the schematic diagram for the transmitter (fig. 254).

### 154. Transmitter, Theory of Transmitter Filter (fig. 86)

Transmitter filter FL1 (FL2) is a hermetically sealed unit containing a band-pass filter used to restrict the channel output signals to their assigned frequency band. Terminals 2 and 4 are internally strapped and form the ground side of the filter network. The band-pass filter accepts signals from buffer amplifier V1A at terminal 3 and passes a band of frequencies 110 cps wide, symmetrically located about the center frequency of the channel. The output signals from terminal 1 are made available at CHANNEL OUTPUT jacks J1 and J2 (J5 and J6) and leave the transmitter at terminal J (K) of connector J16. The input impedance of the filter at terminals 3 and 4 is 7,500 ohms and the output impedance at terminals 1 and 2 is 600 ohms. The channel and frequency designations of the transmitter filter are given on the schematic diagram for the transmitter (fig. 254).

## Section IV. THEORY OF SUBGROUP MODULATOR

### 155. General

The SUBGROUP MODULATOR combines two bands of frequencies from 1,785 to 2,975 cps into one band with a frequency range from 425 to 2,975 cps. Each input band contains telegraph signals from eight transmitter channels. Signals from the odd-numbered channels of the transmitters follow a path through the SUBGROUP MODULATOR designated as the direct path, and the frequencies of these signals remain unchanged. Signals from the even-numbered channels of the transmitters follow a different path through the SUBGROUP MODULATOR designated as the translated path. Here they are

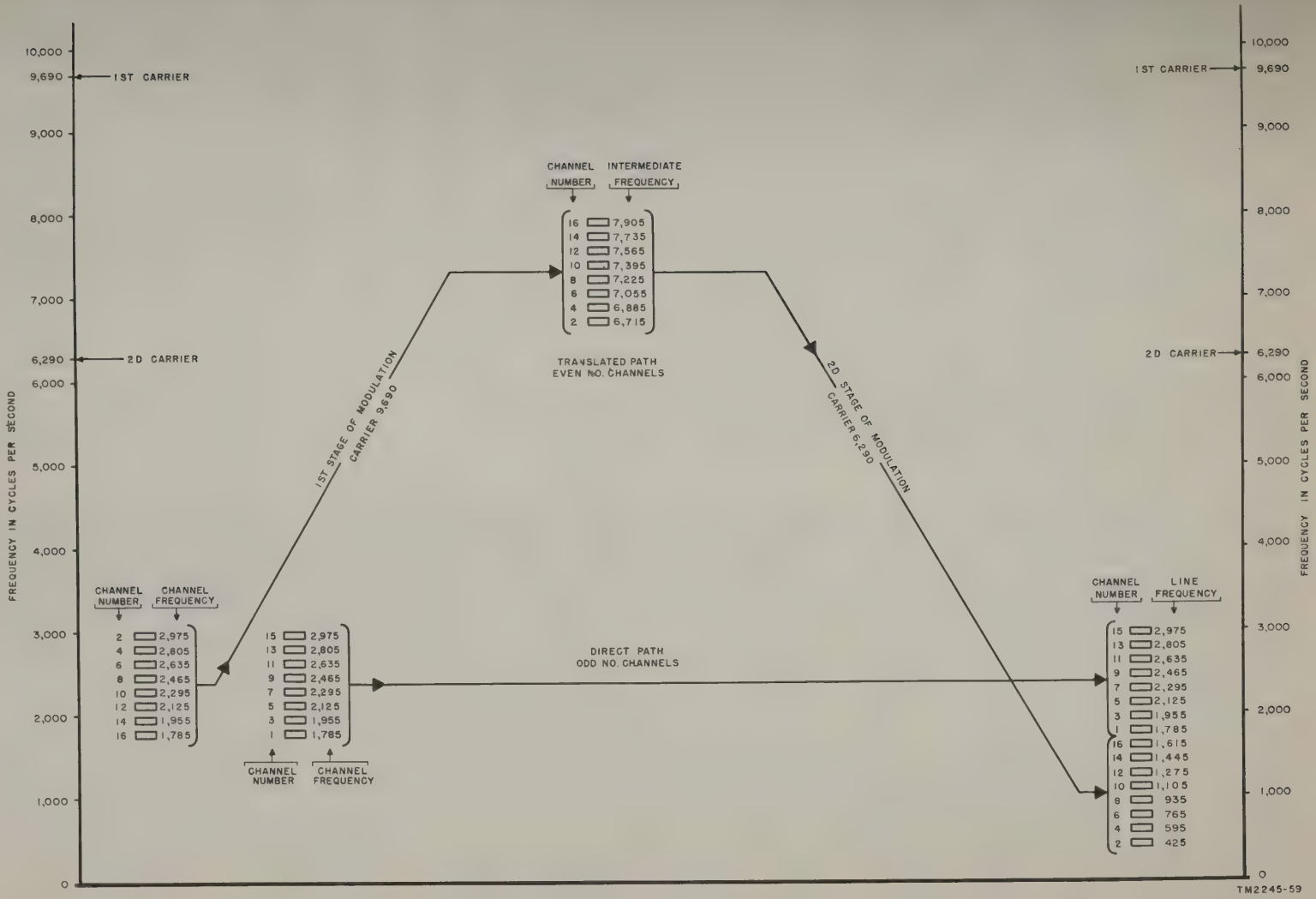



*Figure 87. SUBGROUP MODULATOR, frequency translation chart.*

shifted in frequency twice as shown in the frequency translation chart (fig. 87). The first frequency translation, using a 9,690 cps carrier, inverts and shifts the signals in frequency to a higher position in the spectrum extending from 6,715 to 7,905 cps. The second frequency translation, using a 6,290 cps carrier, places the signals in a lower position from 425 to 1,615 cps. Frequency translation is accomplished in the SUBGROUP MODULATOR by means of suppressed carrier modulation and single-sideband transmission. The combined signal output of the SUBGROUP MODULATOR occupies a bandwidth between 425 and 2,975 cps and contains 16 telegraph channels.

## 156. SUBGROUP MODULATOR, Block Diagram Analysis

(fig. 88)

The signal paths of the SUBGROUP MODULATOR are shown in the block diagram. For a detailed analysis of the SUBGROUP MODULATOR circuit, refer to paragraph 157 and the schematic diagram (fig. 90).

*a. Direct Path.* Transformer T19 is the input transformer for the direct path of the SUBGROUP MODULATOR. Input signals in the frequency range from 1,785 to 2,975 cps from the odd-numbered channels of the transmitters are fed through transformer T19 to a 23-db pad. This is a fixed pad which inserts an attenuation of 23 db in the direct path to make its transmission loss equal to that of the translated path. From here the signals are routed through a branching network to transformer T20 which is the output transformer for both the direct and translated paths. Transformer T12 delivers the signals to the output after which they are fed to the LEVEL CONTROL & PLATE SUPPLY.

*b. Translated Path.* Input signals in the frequency range from 1,785 to 2,975 cps from the even-numbered channels of the transmitters are fed to the input of converter Z2. Here the signals modulate a carrier frequency of 9,690 cps generated within the converter. The upper sideband resulting from the modulation process occupies a band of frequencies between 11,475 and 12,665 cps, and the lower sideband extends from 6,715 to 7,905 cps. The carrier frequency and the input signal frequencies are suppressed by balance and do not appear at the converter output. The upper and lower sideband frequencies are fed from the converter to mod filter 1. This filter has a pass band from 6,600 to 8,000 cps which transmits the lower sideband frequencies and rejects the upper sideband. The lower sideband signals (6,715 to 7,905 cps) are fed to the input of modulator Z1. In modulator Z1, a carrier frequency of 6,290 cps from carrier supply Y1 is modulated by the signal frequencies from 6,715 to 7,905 cps for the second stage of frequency translation. The upper sideband resulting from this modulation occupies a band of frequencies from 13,005 to 14,195 cps, and the lower sideband extends from 425 to 1,615 cps. Frequencies in these sidebands are fed from modulator Z1 to mod filter 2. This is a low-pass filter with a cutoff frequency of 1,700 cps which transmits the lower sideband frequencies and rejects the upper sideband. The lower sideband signals are next applied to an 8-db pad which provides the correct terminating impedance for mod filter 2 and acts as a buffer between the filter and the branching network which follows. The signals in the translated path enter the branching network where they are combined with the direct path signals and continue to the output of the modulator as described in *a* above.

*c. Power Supply.* Plate Supply PS1 furnishes the heater voltage and B-plus voltage required for the operation of converter Z2 and carrier supply Y1 of the SUBGROUP MODULATOR. Input power for plate supply PS1 is regulated 230 volts ac at 50 or 60 cps. Its output provides a B-plus voltage of 200 volts dc and a heater voltage of 6.3 volts ac.

## 157. SUBGROUP MODULATOR Schematic Diagram Analysis

(fig. 90)

The signal paths of the SUBGROUP MODULATOR are shown in detail on the schematic diagram (fig. 90).

*a. Direct Path.* Signals for the single-ended direct path input of the SUBGROUP MODULATOR enter at terminal G of connector J23 with a signal ground on terminal F. From here the signals are applied in turn to the DIRECT PATH INPUT BUS jacks J5 and J6 and the DIRECT PATH INPUT EQUIP jacks J7 and J8, and then sent to the output coupler Z3. The DIRECT PATH INPUT MONITOR jacks J9 and J10 are bridged across the signal circuit following the DIRECT PATH INPUT EQUIP jacks. The signals enter the output coupler at terminals 1 and 2 of terminal board TB10 and are applied to

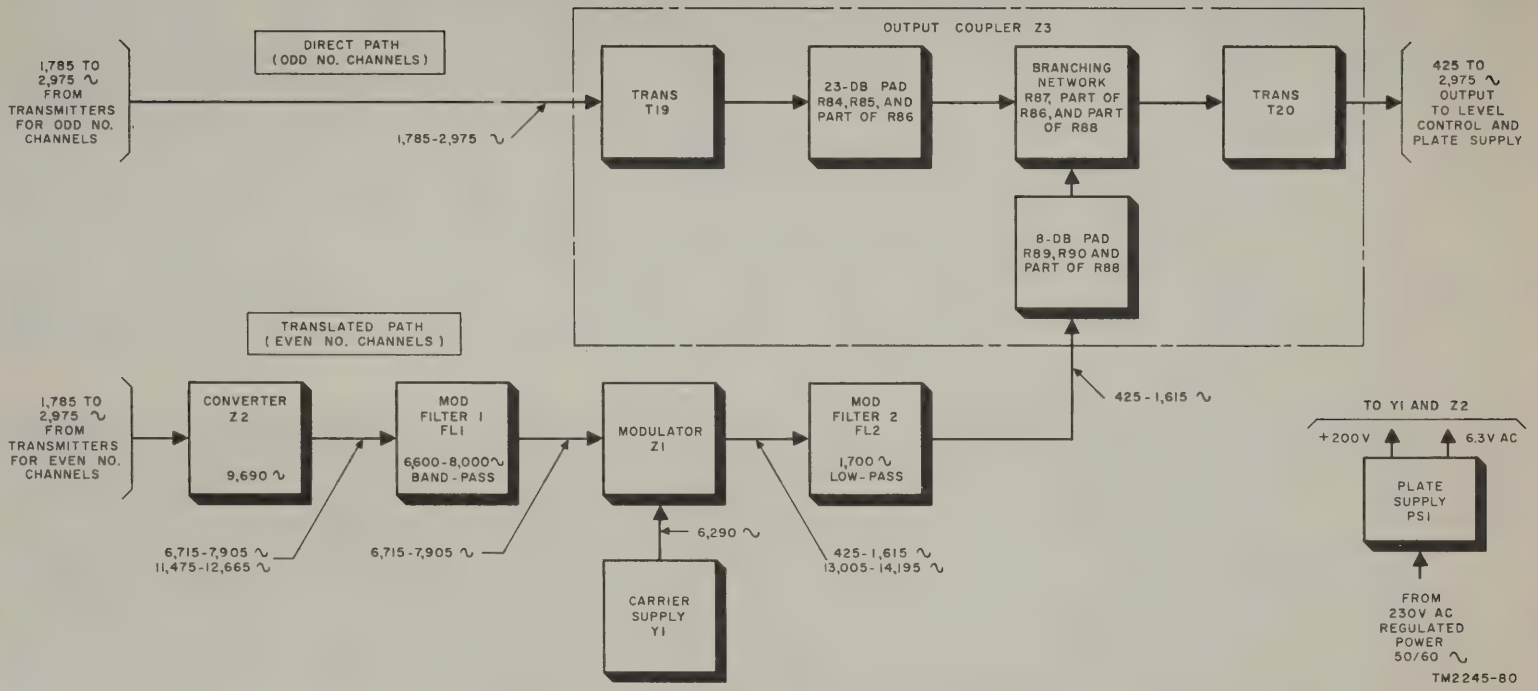



*Figure 88. SUBGROUP MODULATOR, block diagram.*

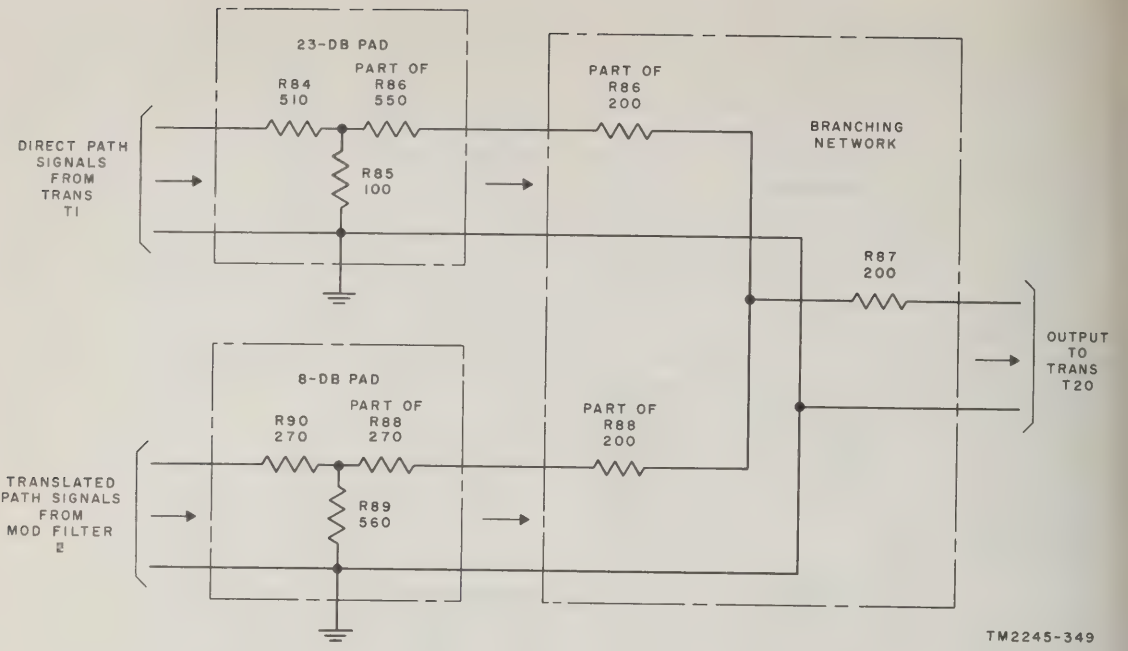



*Figure 89. SUBGROUP MODULATOR, branching network, 8- and 23-db pads, simplified schematic diagram.*

transformer T19 at terminals 1 and 2. The signals are taken from terminals 4 and 3 of transformer T19 and applied to a pad composed of resistors R84, R85, and part of R86 (fig. 89). This is a T pad which inserts a fixed 23-db loss in the direct path to make the loss of the direct path equal to that of the translated path. The resistance in the series arms of the T is made up of resistor R84 and 550 ohms of 750-ohm resistor R86 and in the shunt arm, of resistor R85. The signals next pass through a branching network which is a single-ended, three-way, 6-db pad, partly in the direct path and partly in the translated path, (*b* below). The direct path signals are routed through this network to primary terminals 3 and 4 of transformer T20 which couples the 600-ohm single-ended circuit to the 600-ohm balanced circuit which follows. The signals are next taken off secondary terminals 1 and 2, and leave the output coupler at terminals 5 and 6 of terminal board TB10. From here they are applied to the OUTPUT EQUIP jacks J17 and J18 and OUTPUT LINE jacks J19 and J20. The OUTPUT MONITOR jacks J21 and J22 are bridged across the signal circuit following the OUTPUT LINE jacks The signals pass to the output of the SUBGROUP MODULATOR at terminals A and B of connector J23.

*b. Translated Path.* Signals for the single-ended translated path input of the SUBGROUP MODULATOR enter at terminal H of connector J23 with a signal ground on terminal F. From here the signals are applied in turn to the TRANSLATED PATH INPUT BUS jacks J11 and J12 and the TRANSLATED PATH INPUT EQUIP jacks J13 and J14 and then sent to converter Z2. The TRANSLATED PATH INPUT MONITOR jacks J15 and J16 are bridged across the signal circuit following the TRANSLATED PATH INPUT EQUIP jacks. The signals enter the converter at terminals 1 and 2 of terminal board TB7. In the converter, the signals modulate a carrier frequency of 9,690 cps generated within the converter. The carrier frequency and the input frequencies are suppressed. The two sidebands that result from the modulation process appear at converter output terminals 3 and 4. From here the signals pass to mod filter 1 where they enter by way of terminals 3 and 4. Mod filter 1 is a band-pass filter which transmits the lower sideband frequencies and rejects the upper sideband. Signals in the remaining sideband leave via terminals 1 and 2 of mod filter 1 and enter modulator Z1 at input terminals 1 and 2 of terminal board TB3. In the modulator the signals undergo the second frequency translation, modulating a carrier fre-

quency of 6,290 cps supplied (from terminals 1 and 2 of terminal board TB5 on carrier supply Y1 to terminals 5 and 6 of terminal board TB3 on modulator Z1). The carrier and input frequencies are again suppressed. The two sidebands resulting from the modulation process appear at the modulator output terminals 3 and 4. From here the signals pass to mod filter where they enter by way of terminals 3 and 4. Mod filter 2 is a low-pass filter which passes the lower sideband signals and rejects the upper sideband. Signals in the lower sideband leave via terminals 1 and 2 and enter the output coupler Z3 at terminals 3 and 4 of terminal board TB10. In the output coupler the signals are next applied to an 8-db T pad composed of resistors R89, R90, and part of R88 (fig. 89). The resistance in the series arm of the T pad is made up of resistor R90 and 270 ohms of resistor R88 and in the shunt arm, of resistor R89. This pad provides the proper terminating impedance for mod filter 2 and acts as a buffer between the filter and the branching network which follows. The branching network combines the signals in the direct path with the signals in the translated path. The branching network is a single-ended, three-way, 6-db pad, which transmits signals in the inputs from the diredt path and translated path to a common output with a 6-db loss for each path, and an impedance match for all three of the interconnected 600-ohm circuits. The network is made up of 200-ohm resistor R87, 200 ohms of resistor R86, and 200 ohms of resistor R88. The configuration of the branching network and the 8-db and 23-db pads are shown in simplified schematic diagram (fig. 89). From this point, the combined signal frequencies are transmitted to the output of the SUBGROUP MODULATOR (*a* above).

*c. Power Supply.* The 230-volt ac regulated power is brought in at connector J24 and applied through fuses F1 and F2 to terminals 1 and 4 of input transformer T3 in plate supply PS1. Fuses F1 and F2 are inserted in each side of the powerline to protect the SUBGROUP MODULATOR against overload. BLOWN FUSE INDICATORS I 1 and I 2 are bridged across fuses F1 and F2. Should either fuse blow, the input power will be applied directly across the corresponding neon indicator lamp, causing it to glow. The connection between terminals 2 and 3 of transformer T3 places the primary windings in series for operation with 230 volts ac. The output of plate supply PS1 appears at terminal 1 of terminal board TB4 as 200 volts dc to supply B-plus voltage for the tubes in converter Z2 and carrier supply Y1. The 6.3-volt ac heater voltages are supplied to these subassemblies from terminals 3 and 5 of terminal board TB4.

*d. Jacks.* Three groups of jacks are used to provide connections to the SUBGROUP MODULATOR circuits for measuring and monitoring the direct path input, the translated path input, and the SUBGROUP MODULATOR output. Two groups each contain two BUS jacks, two EQUIP jacks, and two MONITOR jacks, used with cords equipped with twin plugs. In the remaining group are two EQUIP jacks, two LINE jacks, and two MONITOR jacks. The MONITOR jacks are always bridged across the output side of each group with respect to the signal path. In the input for each signal path, the INPUT BUS jacks allow for measurement of the bus signal levels. The INPUT EQUIP jacks for each path permit the introduction of test signals into the input circuit associated with each path. The OUTPUT EQUIP jacks permit measurement of the level of the SUBGROUP MODULATOR output signals. The OUTPUT LINE jacks permit test signals to be applied to the output circuit of the SUBGROUP MODULATOR. The MONITOR jacks permit monitoring of the input circuit associated with each path, and of the SUBGROUP MODULATOR output circuit.

*Figure 90. SUBGROUP MODULATOR, schematic diagram.*

(Contained in separate envelope)

## 158. SUBGROUP MODULATOR, Converter, Block Diagram Analysis

(fig. 91)

The converter consists of a 19.38-kc oscillator circuit, a 19.38-kc to 9.69-kc frequency divider circuit, a square wave amplifier circuit, and a signal modulator. For a detailed circuit analysis of the converter, refer to paragraph 159 and the schematic diagram.

*a. Oscillator Circuit, 19.38-Kc.* The 19.38-kc oscillator circuit consists of oscillator V10A, tuned amplifier V10B, and crystal Y2. The circuit oscillates at the natural frequency of crystal Y2 which is located in a regenerative feedback path from the output of the tuned amplifier to the input of the oscillator. Tuned amplifier V10B, in conjunction with transformer T12 and capacitor C20, selects and amplifies the 19.38 kc in the output of the oscillator and discards harmonics.

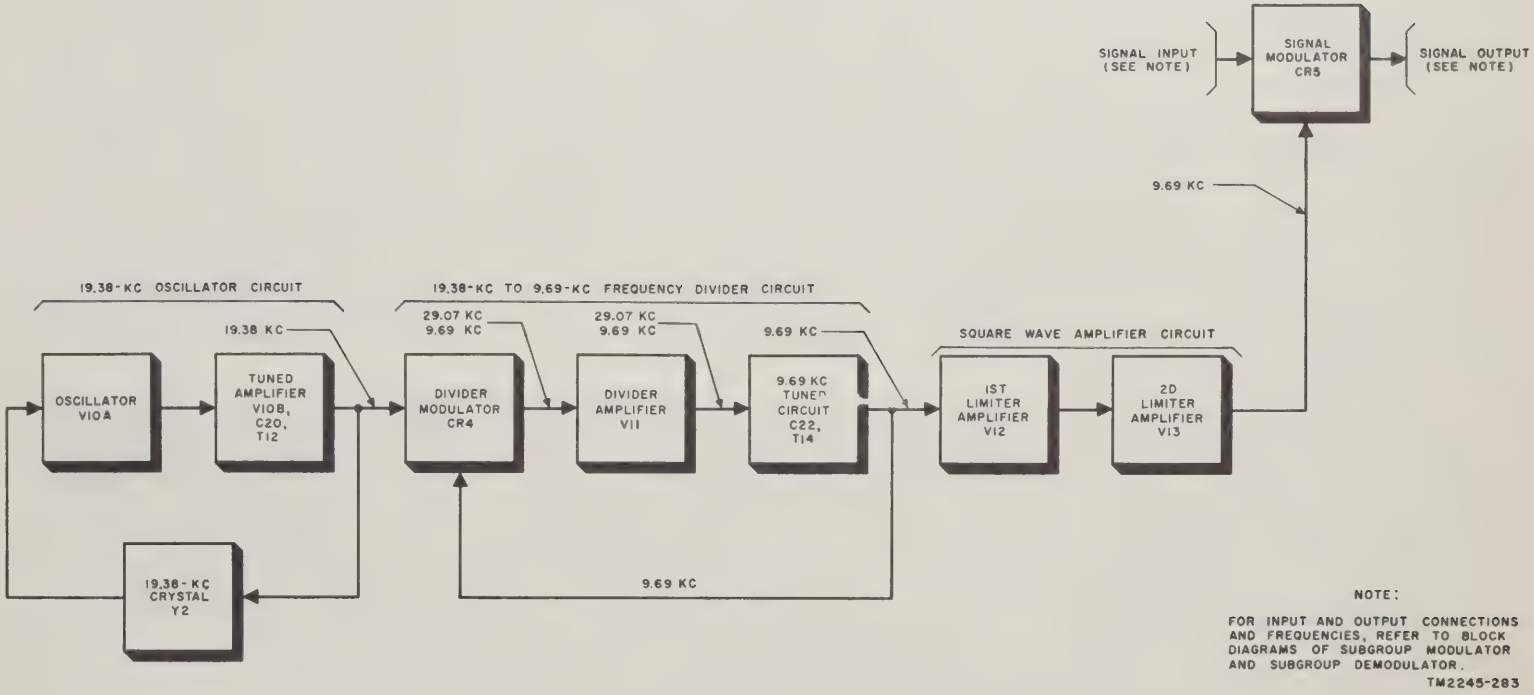



*Figure 91. SUBGROUP MODULATOR, converter, block diagram.*

The amplifier output is delivered to the 19.38- to 9.69-kc frequency divider circuit.

*b. Frequency Divider Circuit, 19.38- to 9.69-Kc.* The 19.38- to 9.69-kc frequency divider circuit uses a double-balanced modulator CR4, a divider amplifier V11, and a 9.69-kc tuned circuit. In a regenerative frequency divider of this type, the divider modulator is double-balanced in that both input frequencies are suppressed by balance so that neither appears in the modulator output. Only the sum and the difference frequencies resulting from the modulation process are present in the output. The arrangement is regenerative in that the output frequency of the divider modulator is modulated with the input to produce the same output frequency. Since the output frequency subtracted from the input frequency equals the output, the output frequency must be exactly one-half the input, thereby performing a two-to-one frequency division. In the divider modulator CR4, the 19.38-kc input is modulated with a frequency of 9.69 kc fed back from the output. Both the sum and the difference frequencies, 9.69 kc and 29.07 kc, appear in the output but the input frequency does not. The output frequencies are amplified by divider amplifier V11, after which the 29.07-kc output is discarded by the 9.69-kc tuned circuit made up of transformer T14 and capacitor C22. This tuned circuit selects the 9.69-kc output and feeds it to the input of the square wave amplifier circuit, and also feeds it back to the divider modulator.

*c. Square Wave Amplifier Circuit.* First limiter amplifier V12 accepts the 9.69-kc input and produces a square wave at its output. Amplifier V12 drives the second limiter amplifier V13 which acts as a power amplifier and also improves the wave shape. The square wave output with a frequency of 9.69 kc is then routed to the signal modulator.

*d. Signal Modulator.* In the signal modulator, the 9.69-kc carrier frequency is modulated by signal frequencies from 1,785 to 2,975 cps from the output of the even-numbered channels of the transmitters. The upper sideband resulting from the modulation process occupies a band of frequencies between 11,475 and 12,665 cps, and the lower sideband extends from 6,715 to 7,905 cps. The carrier frequencies and the input signal frequencies are suppressed by balance within the modulator so that only the upper and lower sidebands appear at the output of the converter.

## 159. SUBGROUP MODULATOR, Converter, Schematic Diagram Analysis

(fig. 92)

*a. Oscillator Circuit, 19.38-Kc.* The 19.38 kc oscillator circuit is a stable crystal-controlled oscillator consisting of oscillator stage V10A, crystal Y2 with a natural frequency of 19.38 kc, and tuned amplifier stage V10B, which form a regenerative feedback circuit. Oscillation begins in tube V10A with the amplification of noise on the grid. After further amplification in tube V10B, the noise signals are taken from the center tap at terminal 6 on the primary of transformer T12, and are fed back through blocking capacitor C18 and crystal Y2 to the grid of oscillator V10A. The crystal acts as a sharply tuned series resonant circuit which makes the feedback loop regenerative only at its natural frequency of 19.38 kc. Continued amplification of the 19.38-kc component of the noise sends the oscillator circuit into oscillation at this frequency. In the oscillator stage, resistor R56 is the grid resistor, and resistor R58 provides cathode bias. Resistor R92 serves as the plate load for the stage, and with resistor R57 forms a voltage divider from B-plus to ground; this lowers the plate voltage to limit the output at the plate of V10A and prevents overloading of the crystal. The output of oscillator V10A is fed to the grid of tuned amplifier V10B through coupling capacitor C19. In the tuned amplifier stage, resistor R59 is the grid resistor, and resistor R60 provides cathode bias. The plate voltage is supplied through the primary winding of transformer T12. Signals from the plate of tube V10B are fed into the parallel-tuned circuit, consisting of transformer T12 primary and capacitor C20 in the plate circuit, which presents a high impedance to 19.38 kc and a low impedance to all other frequencies. The ac voltage across this tuned circuit will be almost entirely 19.38 kc with harmonics suppressed, and this is the frequency which is taken from the transformer secondary winding and fed to the divider modulator which follows. The primary-to-secondary impedance ratio of transformer T12 is 10,000-to-400 ohms to provide impedance matching between the oscillator and frequency divider circuits.

*b. Frequency Divider Circuit, 19.38- to 9.69-Kc.* The 19.38- to 9.69-kc frequency divider circuit consists of a double-balanced divider modulator

and a divider amplifier. The input for the divider modulator is a carrier frequency furnished by the 19.38-kc oscillator circuit. The amplified output of the modulator is fed back as the input signal frequency for this stage and is also transformer-coupled to the square wave amplifier circuit which follows. The output frequency is equal to one-half its input carrier frequency, thereby performing a two-to-one frequency division. The divider modulator is made up of varistor CR4 and resistors R61 through R64. The modulator receives the 19.38-kc carrier frequency from transformer T12 of the oscillator circuit. The carrier is applied between the junction of resistors R61 and R62 and the junction of resistors R63 and R64. The 9.69-kc modulating signal is fed back from the divider amplifier and is applied to the modulator across terminals 7 and 3 of varistor CR4. A detailed description of the theory of a balanced modulator is given in *d* below. The upper and lower sidebands in the modulator output at terminals 2 and 6 of varistors CR4 are applied to transformer T13 at terminals 2 and 1 and taken off at terminals 3 and 6. Transformer T13 has a primary-to-secondary impedance ratio of 600 to 60,000 ohms. Capacitor C21 across terminals 3 and 6 of transformer T13 provides filtering to attenuate partially the upper sideband resulting from the modulation process. The lower sideband and the attenuated upper sideband are applied to the grid of the divider amplifier across grid resistor R65. Resistor R66 provides cathode bias for the stage, and resistor R68 drops the screen voltage. Capacitor C23 is the screen bypass capacitor. B-plus voltage is supplied through the primary winding of transformer T14 to the plate of tube V11. The plate load of tube V11 consists of the parallel tuned circuit composed of transformer T14 primary and capacitor C22. The tuned circuit is resonant at 9.69 kc. The 9.69-kc tuned circuit selects the lower sideband and couples it to the transformer secondaries, suppressing the upper sideband and other extraneous frequencies. The 9.69-kc voltage developed across the secondary winding between terminals 6 and 7 is fed back to the divider modulator signal input through resistor R67. The 9.69-kc voltage across the secondary winding between terminals 3 and 5 is applied to the input of the square wave amplifier circuit which follows.

*c. Square Wave Amplifier Circuit.* The square wave amplifier circuit consists of two push-pull stages: a first limiter amplifier V12, which accepts the 9.69-kc sine wave and forms a square wave at its output, directly coupled to a second limiter amplifier V13, which provides further amplification and shaping of the wave form. The 9.69-kc sine wave input is applied from transformer T14 in push-pull to the grids of tube sections V12A and V12B. The voltage in the winding between terminals 4 and 5 is applied to the grid of V12A through resistor R69, and the voltage in the winding between terminals 3 and 4 is applied to the grid of V12B through resistor R70. During the positive half-cycle of the voltage between terminals 4 and 5, the positive potential on the grid of section V12A causes this section of the tube to conduct and its plate current to reach saturation. At the same time, the voltage between terminals 4 and 3 drives the grid of section V12B negative and causes this section of the tube to cut off. During the negative half-cycle of voltage on the grid of section V12A, this section of the tube is cut off while the grid of section V12B becomes positive and its plate current saturates. Cathode bias for the stage is provided by resistor R71. B-plus voltage is supplied to the plates of the first limiter amplifier through resistors R72 and R73. The first and second limiter amplifiers are directly coupled by connections from the plate of section V12A to the grid of section V13A, and from the plate of section V12B to the grid of section V13B. When section V12A of the first limiter amplifier is conducting, plate current flows through resistor R72. This produces a voltage drop which reduces the potential on the grid of section V13A to a very low value and causes this section of the tube to cut off. At the same time, section V12B of the first limiter amplifier is not conducting, so there is no plate current flowing in resistor R73. This drives the grid of section V13B positive and cause this section of the tube to conduct with plate current saturation. When section V12A of the first limiter amplifier is not conducting, the grid of section V13A becomes positive and produces saturation. Meanwhile section V12B is conducting and the grid voltage of section V13B is reduced to produce cut off. B-plus voltage is supplied to the plates of the second limiter amplifier through terminal 2 at the center of the primary winding on transformer T15. Resistor R74 establishes the cathode bias and limits the magnitude of the plate current. During successive half-cycles of the 9.69-kc output, plate current flows alternately from terminal 2 to terminal 3 and from terminal 2 to terminal 1

on the primary winding of transformer T15. A shaping network, consisting of resistor R75 in series with capacitor C24, adjusts the phase relationship between the harmonics of the output wave to maintain a square wave shape. Transformer T15 has a primary-to-secondary impedance ratio of 10,000-to-240 ohms to match the impedance of the square wave amplifier circuit to that of the modulator. The output 9.69-kc square wave is developed in the secondary winding of transformer T15 between terminals 4 and 6. The CARRIER LEVEL control, variable resistor R77 connected in series with resistor R76, adjusts the output of the square wave amplifier circuit to a level suitable for the input of the signal modulator which follows.

*d. Signal Modulator.* The signal modulator is a double-balanced ring modulator in which a carrier frequency is modulated by signal frequencies to produce frequencies in two sidebands while suppressing the carrier and signal frequencies. The modulator circuit consists of transformers T16 and T17, varistor CR5, resistors R78 through R81, and BALANCE control R82. The 9,690-cps carrier voltage is applied between the center tap, terminals 2 and 3, of transformer T16 and the midpoint, terminal 2, of BALANCE control R82. The BALANCE control is a variable resistor inserted between two identical primary windings on transformer T17. The carrier voltage causes the germanium diodes in varistor CR5 to conduct or to cut off, depending upon the carrier polarity. During the positive half-cycle of the carrier, the midpoint of transformer T16 is made positive with respect to the midpoint of resistor R82. As indicated by the arrowheads of the varistor symbol, this polarity is in the direction to cause diodes A and B to have a low resistance to current flow and diodes C and D to have a very high resistance. Carrier current flows through two balanced paths. One is from the center tap of transformer T16 through the upper winding of this transformer and from there through resistor R78, diode B of the varistor, the upper winding of transformer T17, and the upper portion of resistor R82 to its midpoint. The second path is through the lower winding of transformer T16, resistor R81, diode A, the lower winding of transformer T17, and the lower portion of resistor R82. During the negative half-cycle of carrier voltage, a negative potential between the midpoint of transformer T16 and the midpoint of resistor R82 causes the diodes C and D to conduct and diodes A and B to cut off. Carrier current now flows through a path including the upper part of resistor R82, the upper winding of transformer T17, diode D, resistor R80, and the lower winding of transformer T16 as well as through a second path consisting of the lower part of resistor R82, the lower winding of transformer T17, diode C, resistor R79, and the upper winding of transformer T16. In this way the low-resistance connections between transformers T17 and T16 are reversed in direction every time the carrier voltage reverses in polarity. Input signals are brought into the modulator at terminals 1 and 2 of terminal board TB7, and applied to terminals 5 and 6 of transformer T16. The signals developed across the secondary of transformer T16 at terminals 1 and 4 flow through the modulator to terminals 1 and 4 of transformer T17, but their polarity is reversed each time the carrier reverses and interchanges the conducting paths through the varistor. The wave shape produced by this alternation of signal polarity at the carrier rate contains two new frequency sidebands but no carrier or original signal frequencies. The interruption of the original signals by the instantaneous switching action of the germanium diodes and the consequent voltage polarity reversals keep these signal frequencies from appearing across transformer T17. The carrier current flowing in the winding between terminals 1 and 2 of transformer T17 balances the current in the winding between terminals 3 and 4 because the two currents are equal in amplitude but 180° out of phase. Consequently, there is no output carrier voltage at terminals 5 and 6 of transformer T17 and the carrier is said to be suppressed. The degree of carrier suppression depends on the matching of the diodes in varistor CR5, the equivalence of resistors R78, R79, R80, and R81, and the balance between the transformer windings. Any carrier which is not suppressed by balance because of inequalities in these circuit elements appears at terminals 5 and 6 of transformer T17 as carrier leak. Resistors R79 through R81 provide uniform performance of the modulator circuit offsetting any variations in the characteristics of the germanium diodes and also improve the power handling capabilities of the circuit. BALANCE control R82 joining the two primary windings of transformer T17 provides an adjustable refinement of the modulator balance to minimize the carrier leak. Signals at the sideband frequencies are taken off the secondary of transformer T17 at

terminals 5 and 6 and applied to output terminals 3 and 4 of terminal board TB7.

*Figure 92. SUBGROUP MODULATOR, converter, schematic diagram.*

(Contained in separate envelope)

## 160. SUBGROUP MODULATOR, Theory of Mod Filter 1

(fig. 93)

Mod filter 1 is a hermetically sealed unit, containing a band-pass filter used in the translated path of the SUBGROUP MODULATOR. Mod filter 1 accepts the output of the converter at terminals 3 and 4. The band-pass filter passes all frequencies in the band from 6,600 to 8,000 cps, and attenuates all others, removing the upper sideband present in the converter output. The signals leave the filter by way of terminals 1 and 2 and are passed on to modulator Z1 in the translated path of the SUBGROUP MODULATOR.

## 161. SUBGROUP MODULATOR, Theory of Mod Filter 2

(fig. 94)

Mod filter 2 is a hermetically sealed unit, containing a low-pass filter used in the translated path of the SUBGROUP MODULATOR. Mod filter 2 accepts the output of modulator Z1 at terminals 3 and 4. The low-pass filter passes all frequencies below 1,700 cps and attenuates all others, removing the upper sideband present in the modulator output. The signals leave the filter by way of terminals 1 and 2 and are passed on to the 8-db pad in the translated path of the SUBGROUP MODULATOR.

## 162. SUBGROUP MODULATOR, Carrier Supply, Block Diagram Analysis

(fig. 95)

The carrier supply consists of a 25.16-kc oscillator circuit, a 25.16-kc to 6.29-kc frequency divider circuit which divides the oscillator output to 6.29 kc in two steps, and a square wave amplifier circuit which shapes and amplifies the 6.29 kc and delivers it to the modulator. The circuits of the carrier supply are shown on the block diagram (fig. 95), which is discussed in *a*, *b*, and *c* below. For a detailed circuit analysis of the carrier supply, refer to paragraph 163 and the schematic diagram (fig. 96).

*a.* The 25.16-kc oscillator circuit consists of oscillator V5A, tuned amplifier V5B, and crystal Y1. The circuit oscillates at the natural frequency of crystal Y1 which is located in a regenerative feedback path from the output of the tuned amplifier to the input of the oscillator. The tuned amplifier V5B, in conjunction with transformer

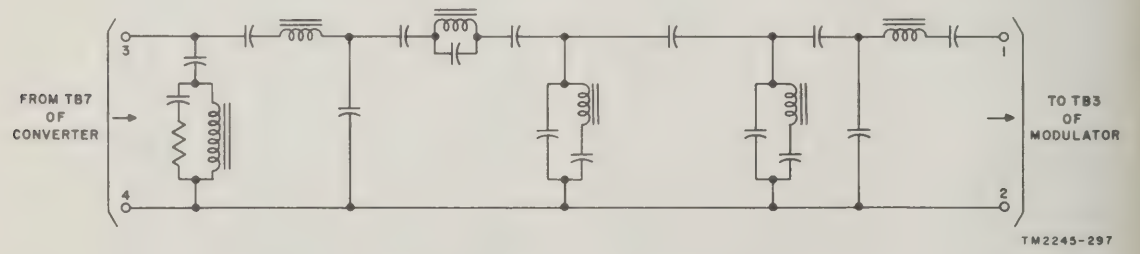



*Figure 93. SUBGROUP MODULATOR, mod filter 1, schematic diagram.*

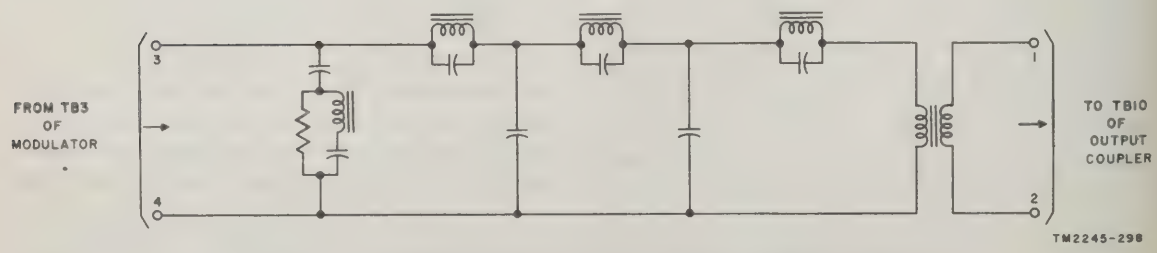



*Figure 94. SUBGROUP MODULATOR, mod filter 2, schematic diagram.*

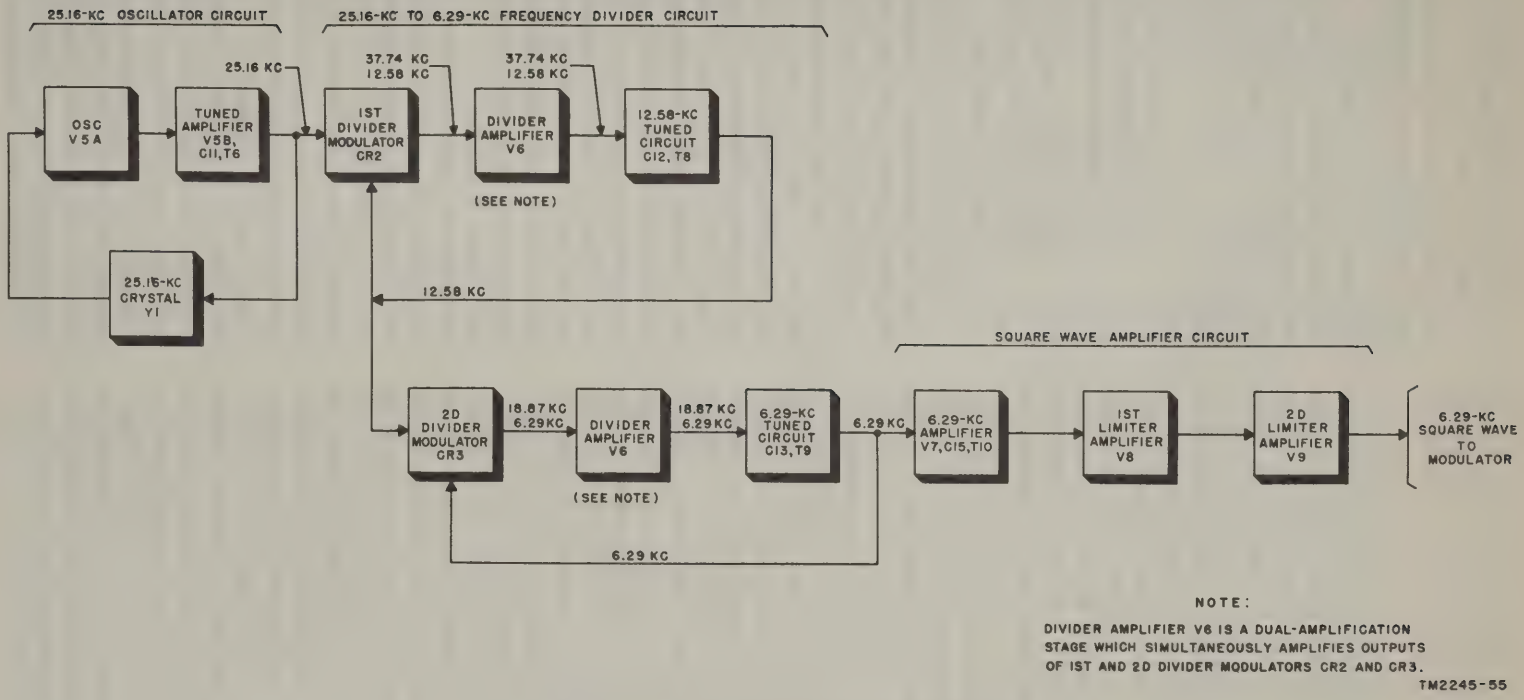



*Figure 95. SUBGROUP MODULATOR, carrier supply, block diagram.*

T6 and capacitor C11, selects and amplifies the 25.16 kc in the output of the oscillator and discards harmonics. The amplifier output is delivered to the first stage of the 25.16-kc to 6.29-kc frequency divider circuit.

*b.* The 25.16- to 6.29-kc frequency divider circuit consists of two double-balanced modulators: first divider modulator CR2 and second divider modulator CR3; a divider amplifier V6, which amplifies the outputs of both modulators simultaneously in a dual-amplification stage; a 12.58-kc tuned circuit, which selects the desired frequency in the first step of frequency division; and a 6.29-kc tuned circuit, which selects the desired frequency in the second step of frequency division. In a regenerative frequency divider of this type, the modulators are double-balanced in that both input frequencies are suppressed by balance so that neither appears in the modulator output. Only the sum and difference frequencies resulting from the modulation process are present in the output. The arrangement is regenerative in that the output frequency of the modulator is modulated with the input frequency to produce the same output frequency. Since the output frequency subtracted from the input frequency equals the output, the output frequency must be exactly one-half the input, thereby performing a two-to-one frequency division. In first divider modulator CR2, the 25.16-kc input is modulated with a frequency of 12.58 kc fed back from the output. Both the sum and the difference frequencies, 12.58 kc and 37.74 kc, appear in the output but the input frequency does not. The output frequencies are amplified by divider amplifier V6, after which the 37.74-kc output is discarded by the 12.58-kc tuned circuit made up of transformer T8 and capacitor C12. This tuned circuit selects the 12.58-kc output and feeds it to the second divider modulator as the input frequency, and also feeds it back to the first divider modulator. In the second divider modulator CR3, the 12.58 kc applied to the input is modulated with a frequency of 6.29-kc fed back from its output. The sum and difference frequencies, 18.87 and 6.29 kc, both appear in the output and are amplified by divider amplifier V6. The unwanted 18.87-kc output is removed in the 6.29-kc tuned circuit made up transformer T9 and capacitor C13. This tuned circuit selects the 6.29-kc output and feeds it to the input of the square wave amplifier circuit which follows, and also feeds it back to the input of the second divider modulator.

*c.* In the first stage of the square wave amplifier circuit, the 6.29-kc amplifier, consisting of amplifier V7, transformer T10, and capacitor C15, amplifies the 6.29-kc signal and removes harmonics and other extraneous frequencies. The output of amplifier V7 drives first limiter amplifier V8 which produces a square wave at its output. Amplifier V8 drives the second limiter amplifier V9 which acts as a power amplifier and also improves the wave shape. The square wave output with a frequency of 6.29 kc is then routed to the modulator.

*Figure 96. SUBGROUP MODULATOR, carrier supply, schematic diagram.*

(Contained in separate envelope)

## 163. SUBGROUP MODULATOR, Carrier Supply, Schematic Diagram Analysis

(figs. 96 through 99)

The circuits of the carrier supply are shown in detail on the schematic diagram (fig. 96) and the simplified schematic diagrams (figs. 97–99).

*a. Oscillator Circuit, 25.16-kc* (fig. 97). The 25.16-kc oscillator consists of oscillator stage V5A, crystal Y1 with a natural frequency of 25.16 kc, and tuned amplifier stage V5B, which form a regenerative feedback circuit. Oscillation begins in tube V5A with the amplification of noise on the grid. After further amplification in tube V5B, the noise signals are taken from the center tap at terminal 6 on the primary of transformer T6 and are fed back through dc blocking capacitor C9 and crystal Y1 to the grid of oscillator V5A. The crystal acts as a sharply tuned series-resonant circuit making the feedback loop regenerative only at its natural frequency of 25.16 kc. Continued amplification of the 25.16-kc component of the noise sends the oscillator circuit into oscillation at this frequency. In the oscillator stage, resistor R26 is the grid resistor, and resistor R28 provides cathode bias. Resistor R91 serves as the plate load for the stage and, with resistor R27, forms a voltage divider from B-plus to ground which lowers the plate voltage to decrease the output at the plate of V5A and prevent overloading the crystal. The output of oscillator V5A is fed to the grid of tuned amplifier V5B through coupling capacitor C10. In the tuned amplifier stage, resistor R29 is the grid resistor and resistor R30 provides cathode bias. The plate voltage is supplied through the primary winding of transformer T6. Signals from the plate of tube V5B are fed

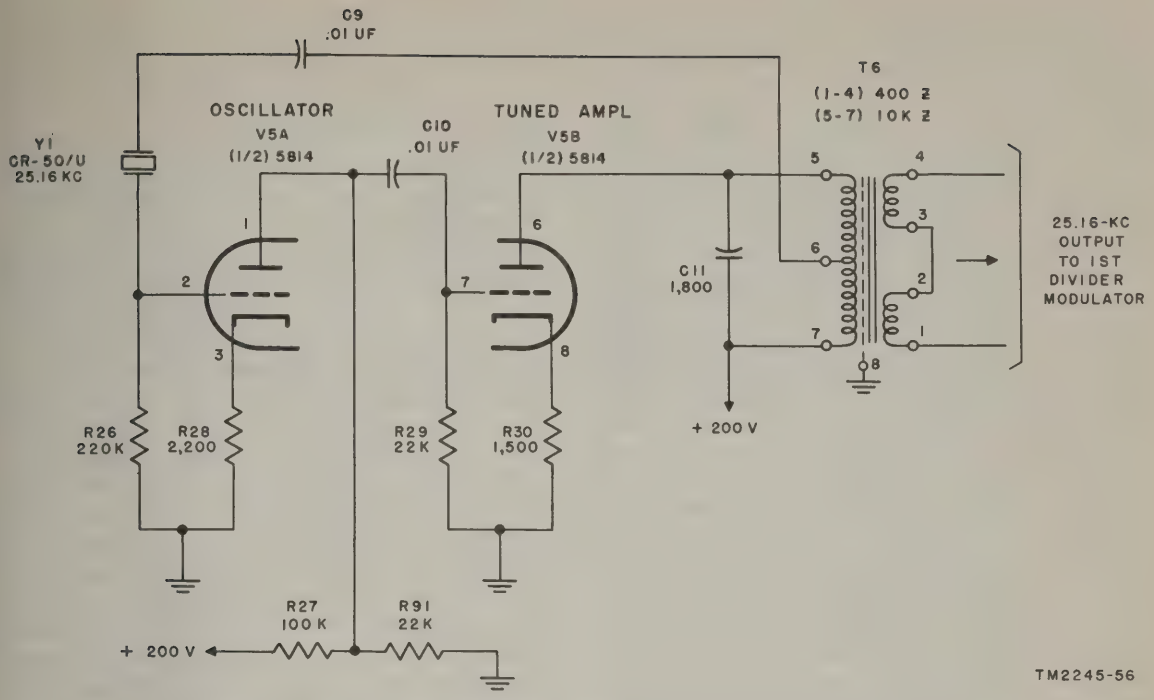



*Figure 97. Carrier supply, 25.16-kc oscillator circuit, simplified schematic diagram.*

into the parallel-tuned circuit, consisting of the transformer T6 primary and capacitor C11 in the plate circuit; this presents a high impedance to 25.16 kc and a low impedance to all other frequencies. The ac voltage across this tuned circuit will be almost entirely 25.16 kc with harmonics suppressed, and this is the frequency which is taken from the transformer secondary winding and fed to the first divider modulator which follows. The primary-to-secondary impedance ratio of transformer T6 is 10,000-to-400 ohms to provide impedance matching between the oscillator and frequency divider circuits.

*b. Frequency Divider Circuit, 25.16- to 6.29-Kc.* (fig. 98). The 25.16- to 6.29-kc frequency divider circuit consists of two series connected double-balanced divider modulators, each of which accomplishes a two-to-one frequency division, and a divider amplifier which amplifies both modulator outputs simultaneously. The input for the first divider modulator is a carrier frequency furnished by the 25.16-kc oscillator circuit. The amplified output of the first modulator is fed back as the input signal frequency for this stage, and as the input carrier frequency for the second divider modulator. The amplified output of the second modulator is fed back to the input as signal for this stage, and is also transformer coupled to the square wave amplifier circuit which follows. The output frequency of each divider modulator is equal to one-half its input carrier frequency, thereby performing a two-to-one frequency division. The first divider modulator is made up of varistor CR2 and resistors R31 through R34. The modulator receives the 25.16-kc carrier frequency from transformer T6 of the oscillator circuit. The carrier is applied between the junction of resistors R31 and R32 and the junction of resistor R33 and R34. The 12.58-kc modulating signal is fed back from the divider amplifier and is applied to the modulator across terminals and 3 of varistor CR2. A detailed description of the theory of a balanced modulator is given in paragraph 159. The upper and lower sidebands in the modulator output at terminals 2 and 6 of varistor CR2 are applied to transformer T7 at terminals 2 and 1 and taken off at terminals 3 and 6. Transformer T7 has a primary-to-secondary impedance ratio of 600 to 60,000 ohms. Both sidebands are fed to the grid of divider amplifier V6 across grid resistor R39. Resistor R40 provides cathode bias for the stage and resistor R43 drops the screen voltage. Capacitor C14 is the screen bypass capacitor. B-plus voltage

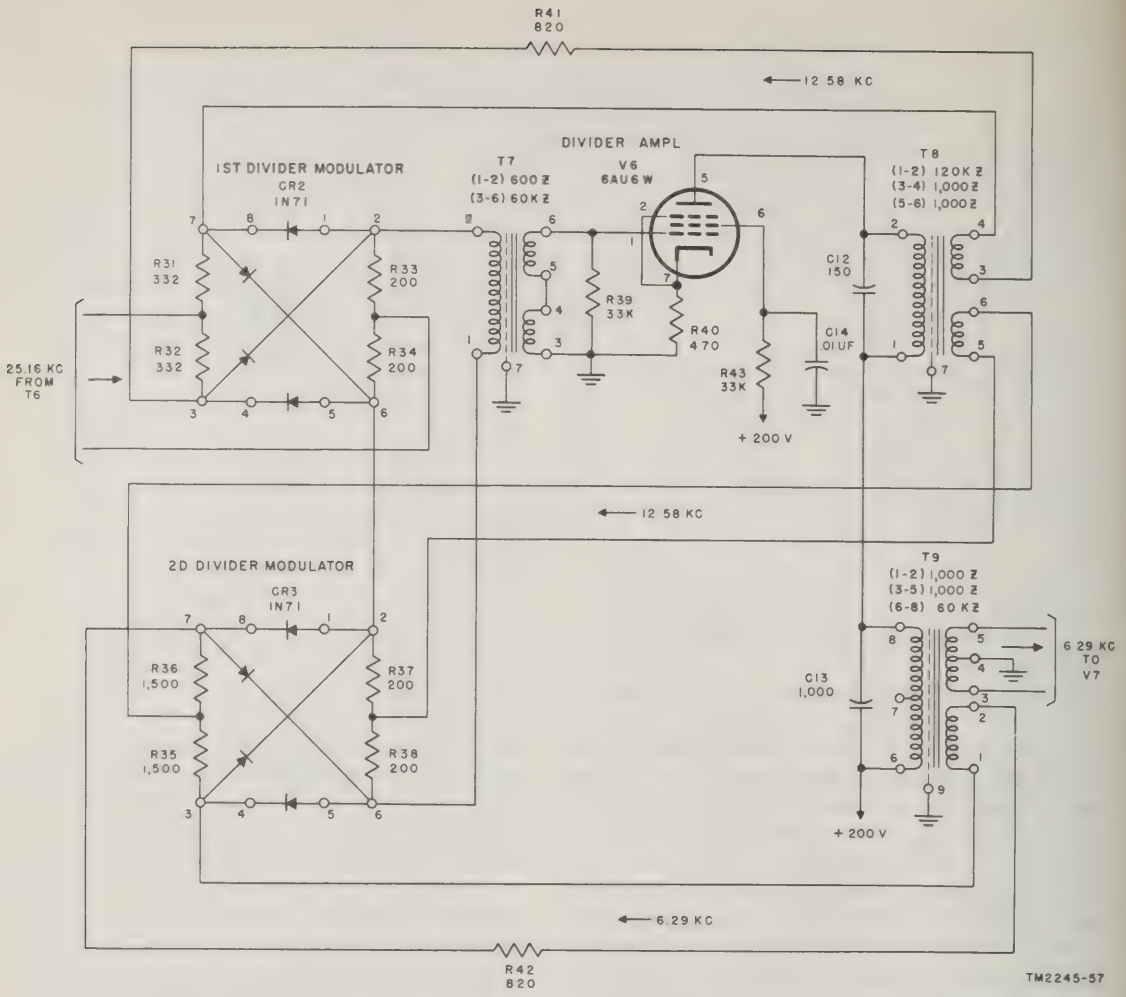



*Figure 98. Carrier supply, 25.16-kc frequency divider circuit, simplified schematic diagram.*

is supplied through the primary windings of transformers T9 and T8 to the plate of tube V6. The plate load of tube V6 consists of two parallel-tuned circuits. One is resonant at 12.58 kc and the other at 6.29 kc. The 12.58-kc tuned circuit, made up of capacitor C12 in parallel with the primary winding of transformer T8, selects the 12.58-kc lower sideband resulting from the first frequency division, and couples it to the transformer secondaries, suppressing the upper sideband and other extraneous frequencies. The 12.58-kc voltage developed across the secondary winding between terminals 4 and 3 is fed back to the first divider modulator input through resistor R41. The 12.58-kc voltage across the secondary winding between terminals 6 and 5 of transformer T8 is applied to the second divider modulator as the carrier frequency for this stage. The second divider modulator consists of varistors CR3 and resistors R35 through R38. The carrier frequency is applied between the junction of resistors R35 and R36 and the junction of resistors R37 and R38. The 6.29-kc modulating signal is fed back from the divider amplifier by way of transformer T9 and applied to the varistor at terminals 7 and 3. The two sidebands in the modulator output at terminals 2 and 6 of the varistor are applied to transformer T7 at terminals 2 and 1 and taken off at terminals 3 and 6. Signals in both sidebands are fed to the grid of the divider amplifier, which operates as a reflex amplifier to amplify the frequencies in the outputs of both divider modulators.

The 6.29-kc tuned circuit, consisting of capacitor C13 in parallel with the primary winding of transformer T9, in the plate circuit of tube V6, selects the 6.29-kc lower sideband, suppressing the upper sideband and other extraneous frequencies. The 6.29-kc voltage, developed across the secondary winding between terminals 2 and 1, is fed back to the second divider modulator input through resistor R42. The 6.29 kc developed in the winding between terminals 3 and 5 is fed to the square wave amplifier circuit which follows.

*c. Square Wave Amplifier Circuit* (fig. 99). The square wave amplifier circuit consists of three push-pull stages: a 6.29-kc amplifier V7, which amplifies and filters the 6.29-kc sine wave; a first limiter amplifier V8, which forms the square wave; and a second limiter amplifier V9, which provides further amplification and shaping of the wave form. The 6.29-kc sine wave input from transformer T9 of the frequency divider circuit is applied in push-pull to the grids of sections V7A and V7B of the 6.29-kc amplifier. The output from the plates of the stage is applied to the primary winding of transformer T10, which is parallel-tuned to 6.29 kc by capacitor C15. B-plus voltage is supplied to the plates through the center tap, terminals 6 and 7, of transformer T10 primary. Cathode bias for the stage is provided by resistor R44. The 6.29-kc amplifier stage amplifies the 6.29-kc sine wave, rejecting harmonics and other extraneous frequencies, and transformer-couples the amplified signal to the first limiter amplifier which follows. Interstage transformer T10 has a primary impedance of 2.5 megohms and two secondary impedances of 100,000 ohms each. The input for the first limiter amplifier is taken from the secondary of transformer T10. The voltage developed in the winding between terminals 4 and 3 is applied through resistor R46 to the grid of section V8A, and the voltage in the winding between terminals 2 and 1 is connected through resistor R45 to the grid of section V8B. During the positive half-cycle of voltage between terminals 4 and 3, the positive potential on the grid of section V8A causes this section of the tube to conduct and its plate current to reach saturation. At the same time, the voltage between terminals 2 and 1 drives the grid section V8B negative and causes this section of the tube to cut off. During the negative half-cycle of the voltage on the grid of section V8A, this section of the tubes is cut off while the grid of section V8B becomes positive and its plate current saturates. Cathode bias for the stage is provided by resistor R47. B-plus voltage is supplied to the plates of the first limiter amplifier through resistors R48 and R49. The first and second limiter amplifiers are directly coupled by connections from the plate of section V8A to the grid of section V9A and from the plate of section V8B to the grid of section V9B. When section V8A of the first limiter amplifier is conducting, plate current flows through resistor R48. This produces a voltage drop which reduces the potential on the grid of section V9A to a very low value and causes this section of the tube to be cut off. At the same time, section V8B of the first limiter amplifier is not conducting, so there is no plate current flowing in resistor R49. This drives the grid of section V9B positive and causes this section of the tube to conduct with plate current saturation. When section V8A of the first limiter amplifier is not conducting, the grid of section V9A becomes positive and produces saturation. Meanwhile, section V8B is conducting and the grid voltage of section V9B is reduced to produce cutoff. B-plus voltage is supplied to the plates of the second limiter amplifier through terminal 2 at the center of the primary winding on transformer T11. Resistor R50 establishes the cathode bias and limits the magnitude of the plate current. During successive half-cycles of the 6.29-kc output, plate current flows alternately from terminal 2 to terminal 3 and from terminal 2 to terminal 1 on the primary winding of transformer T11. A shaping network consisting of resistor R51 in series with capacitor C16 adjusts the phase relationship between the harmonics of the output wave to maintain a square wave shape. Transformer T11 has a primary-to-secondary impedance ratio of 9,600-to-240 ohms to match the impedance of the square wave amplifier circuit to that of the modulator. The output 6.29-kc square wave is developed in the secondary winding of transformer T11 between terminals 4 and 6. The GAIN control, variable resistor R53, which is connected in series with resistor R52, adjusts the output of the carrier supply at terminals 1 and 2 of terminal board TB5 to a level suitable for the input of the modulator.

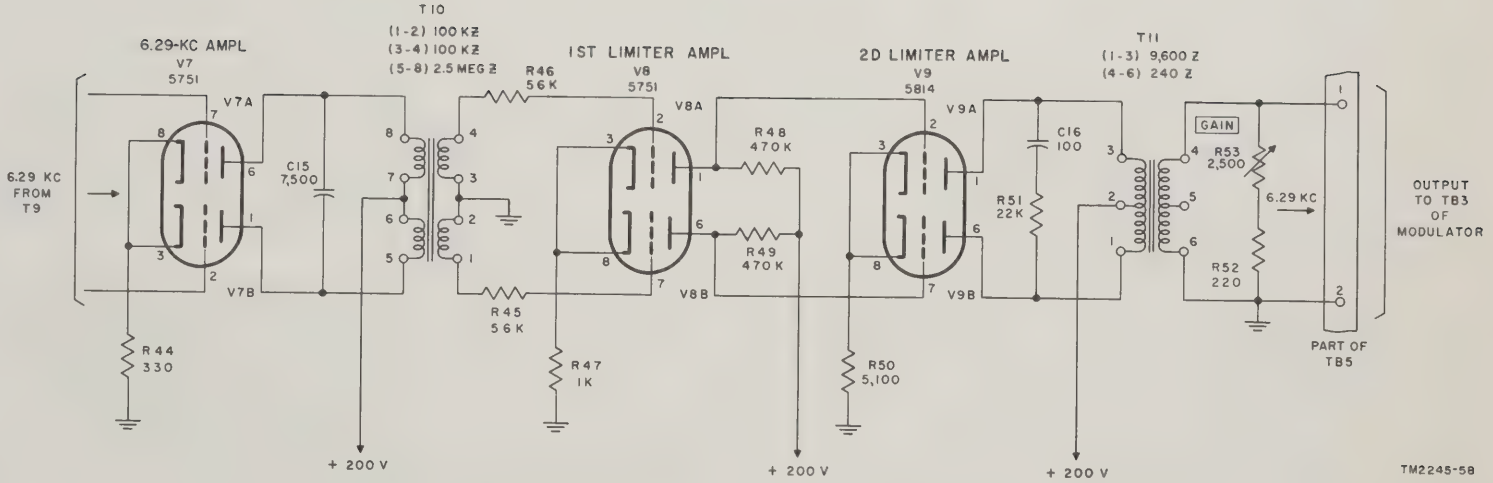



*Figure 99. Carrier supply, square wave amplifier circuit, simplified schematic diagram.*

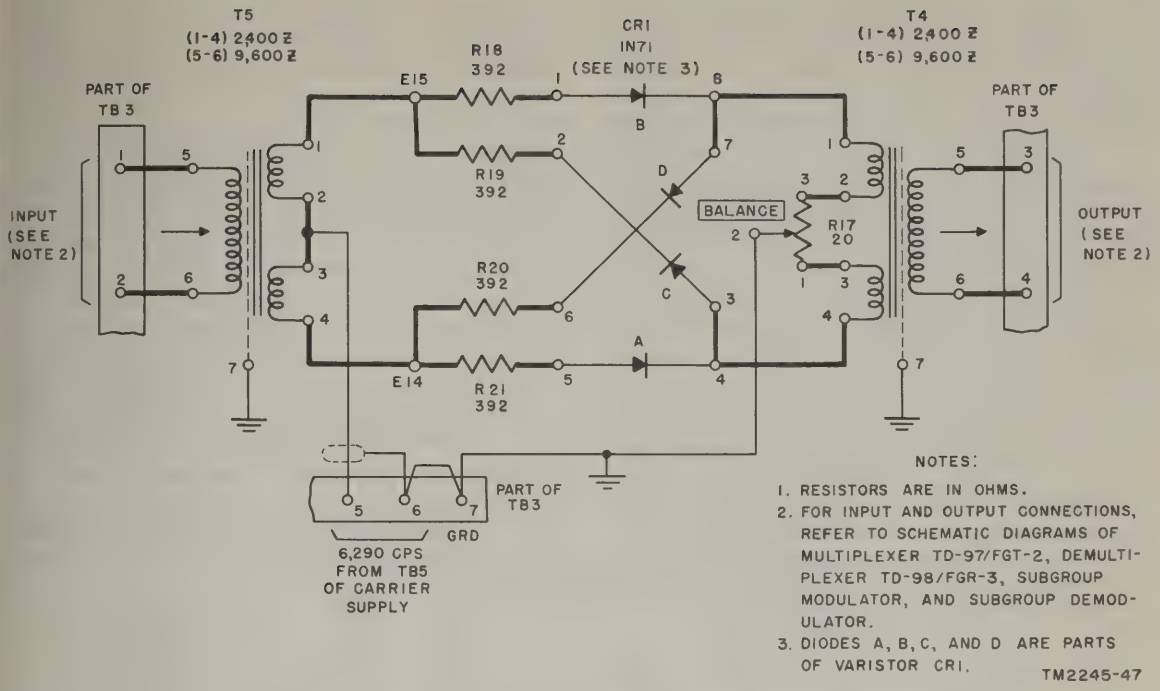



*Figure 100. SUBGROUP MODULATOR, modulator, schematic diagram.*

## 164. SUBGROUP MODULATOR, Theory of Modulator

(fig. 100)

The modulator is a double-balanced ring modulator circuit in which a carrier frequency is modulated by signal frequencies to produce frequencies in two sidebands while suppressing the carrier and signal frequencies. The modulator circuit consists of transformers T4 and T5, varistor CR1, resistors R18 through R21, and BALANCE control R17. The 6,290-cps carrier frequency from the carrier supply is brought into the modulator at terminals 5 and 6 of terminal board TB 3. The carrier voltage is applied between the center tap, terminals 2 and 3, of transformers T5 and the midpoint, terminal 2, of BALANCE control R17. The BALANCE control is a variable resistor inserted between two identical primary windings on transformer T4. The carrier voltage causes the germanium diodes in varistor CR1 to conduct, or to cut off, depending upon the carrier polarity. During the positive half-cycle of the carrier, the midpoint of transformer T5 is made positive with respect to the midpoint of resistor R17. As indicated by the arrowheads of the varistor symbol, this polarity is in the direction to cause diodes A and B to have a low resistance to current flow and diodes C and D to have a very high resistance. Carrier current flows through two balanced paths. One is from the center tap of transformer T5 through the upper winding of this transformer and from there through resistor R18, diode B of the varistor, the upper winding of transformer T4, and the upper portion of resistor R17 to its midpoint. The second path is through the lower winding of transformer T5, resistor R21, diode A, the lower winding of transformer T4, and the lower portion of resistor R17. During the negative half-cycle of carrier voltage, a negative potential between the midpoint of transformer T5 and the midpoint of resistor R17 causes the diodes C and D to conduct and diodes A and B to cut off. Carrier current now flows through a path including the upper part of resistor R17, the upper winding of transformer T4, diode D, resistor R20, and the lower winding of transformer T5 as well as through a second path consisting of the lower part of resistor R17, the lower winding of transformer T4, diode C, resistor R19, and the upper winding of transformer T5. In this way the low-resistance connections between transformers T4 and T5 are reversed in direction every time the carrier voltage reverses in polarity. Input signals are brought into the modulator at terminals 1 and 2 of terminal board

TB3 connected to terminals 5 and 6 of transformer T5. The signals developed across the secondary of transformer T5 at terminals 1 and 4 flow through the modulator to terminals 1 and 4 of transformer T4, but their polarity is reversed each time the carrier reverses and interchanges the conducting paths through the varistor. The wave shape produced by this alternation of signal polarity at the carrier rate contains two new frequency sidebands but no carrier or original signal frequencies. The interruption of the original signals by the instantaneous switching action of the germanium diodes and the consequent voltage polarity reversals keep these signal frequencies from appearing across transformer T4. The carrier current flowing in the winding between terminals 1 and 2 of transformer T4 balances the current in the winding between terminals 3 and 4 because the two currents are equal in amplitude but 180° out of phase. Consequently, there is no output carrier voltage at terminals 5 and 6 of transformer T4 and the carrier is said to be suppressed. The degree of carrier suppression depends on the matching of the diodes in varistor CR1, the equivalence of resistors R18, R19, R20, and R21, and the balance between the transformer windings. Any carrier which is not suppressed by balance because of inequalities in these circuit elements appears at terminal 5 and 6 of transformer T4 as *carrier leak*. Resistors R18 through R21 provide uniform performance of the modulator circuit, offsetting any variations in the characteristics of the germanium diodes and also improving the power handling capabilities of the circuit. BALANCE control R17, together with the two primary windings of transformer T4, provides an adjustable refinement of the modulator balance to minimize the carrier leak. Signals at the sideband frequencies are taken off the secondary of transformer T4 at terminals 5 and 6 and applied to output terminals 3 and 4 of terminal board TB3.

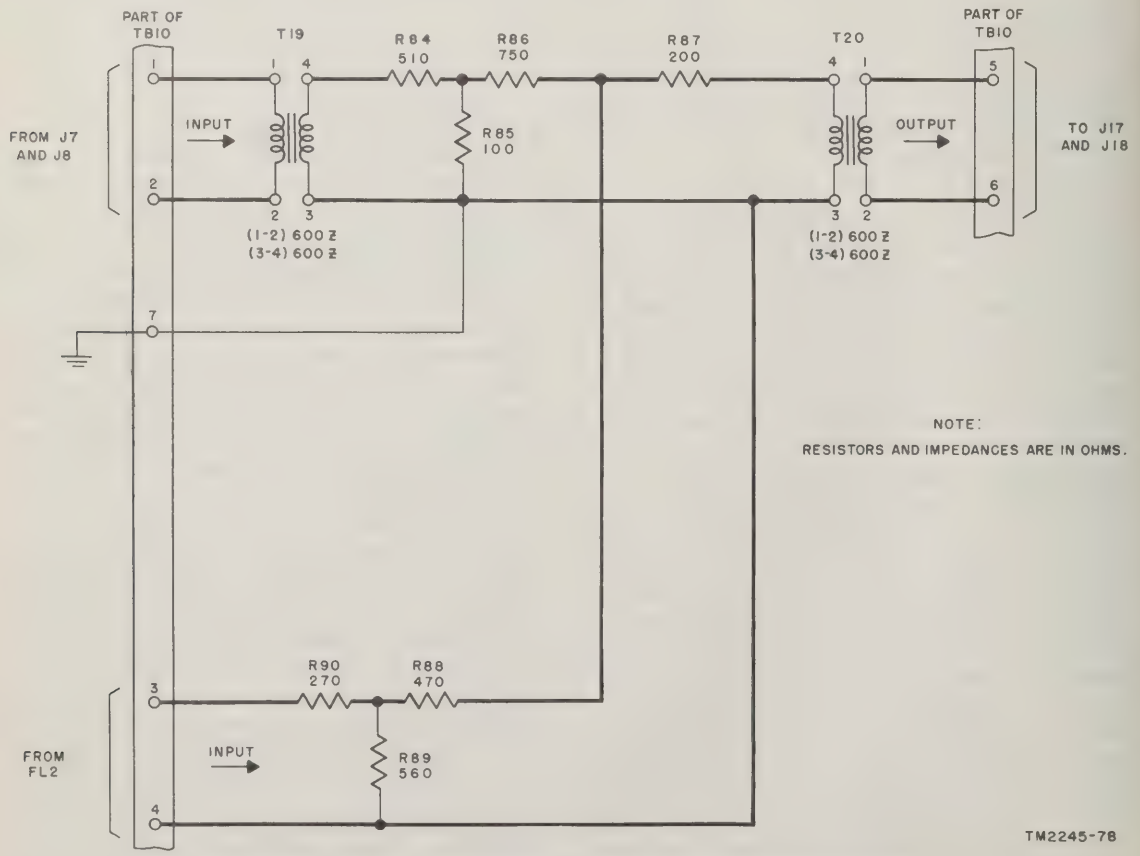



*Figure 101. SUBGROUP MODULATOR, output coupler, schematic diagram.*

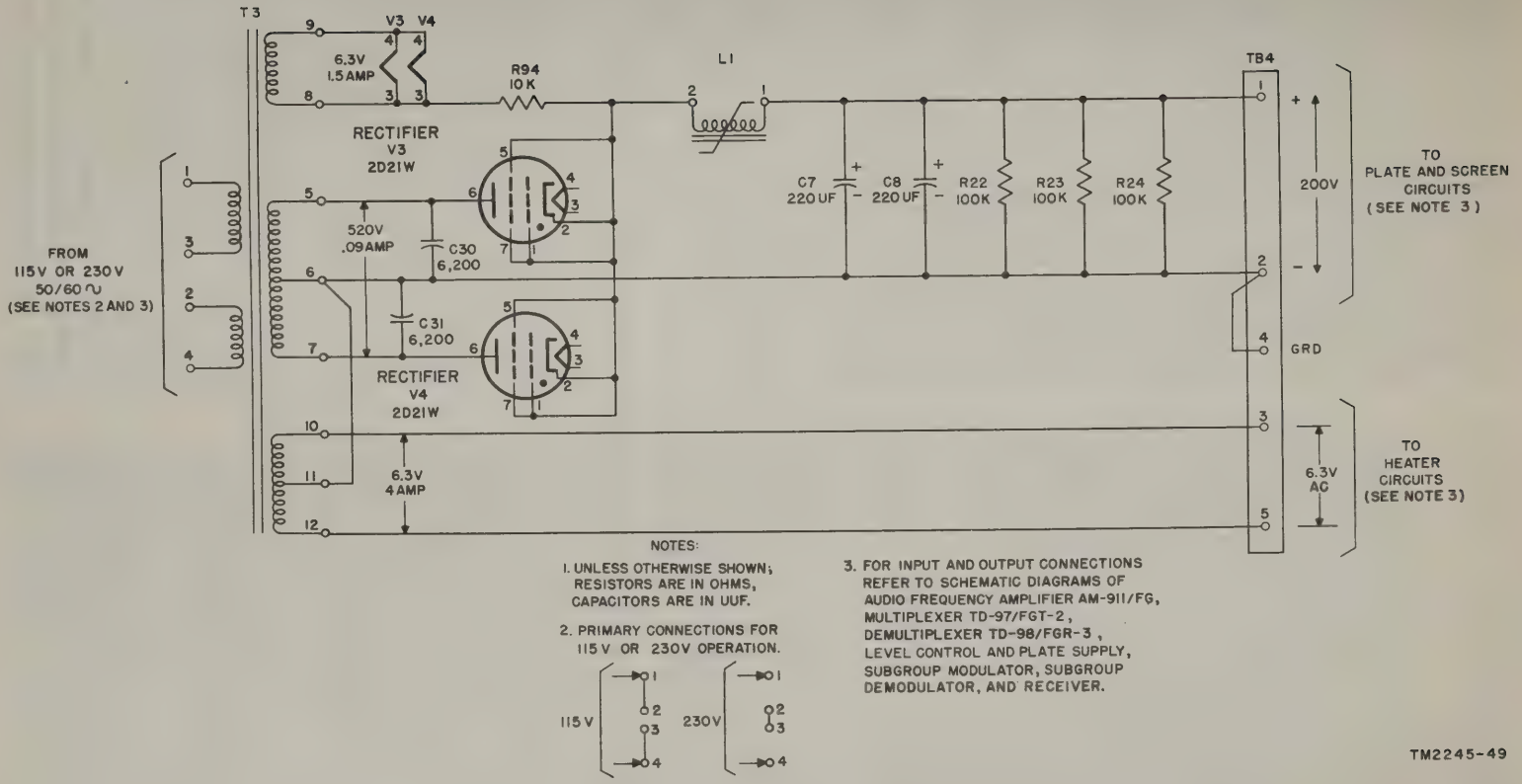



*Figure 102. SUBGROUP MODULATOR, plate, supply schematic diagram.*

## 165. SUBGROUP MODULATOR, Theory of Output Coupler

(fig. 101)

Output coupler Z3 contains transformer T19 and a pad consisting of resistor R84, R85, and part of R86 in the direct path of the SUBGROUP MODULATOR, and a pad consisting of resistors R89, R90, and part of R88 in the translated path. This subassembly also contains the branching network consisting of resistors R87, part of R86, and part of R88, which combines signals from both paths, and output transformer T20. The configuration of the branching network and of both pads is shown in figure 89. The output coupler accepts signals from the direct path in the 1,785- to 2,975-cps range and from the translated path in the 425- to 1,615-cps range, and passes the combined signals to the output of the SUBGROUP MODULATOR.

## 166. SUBGROUP MODULATOR, Theory of Plate Supply

(fig. 102)

The plate supply is a conventional full-wave rectifier circuit which accepts a 115-volt or 230-volt ac input at 50 or 60 cps and delivers an output of 200 volts dc for the vacuum tube plate and screen circuits and 6.3 volts ac for the heater circuits. The ac input is applied to the primary of transformer T3 with the winding between terminals 1 and 3 connected in series with the winding between terminals 2 and 4. The voltage developed between terminals 5 and 7 of the secondary is applied to the plates of rectifiers V3 and V4, both type 2D21 thyratrons. In the positive half-cycle of the applied voltage, rectifier V3 conducts, and in the negative half-cycle rectifier V4 conducts. A pulsating dc voltage is developed between the cathodes of the tubes and terminal 6 of the transformer secondary. The dc output is applied through a filter, consisting of inductor L1 and capacitors C7 and C8, to terminals 1 and 2 of terminal board TB4. Terminal 2 is connected to an external ground in common with terminal 4. Inductor L1 is a swinging choke with inductance that varies with its average current and provides some voltage regulation. Resistors R22 through R24 are load resistors. Heater voltages at 6.3 volts ac for tubes V3 and V4 are taken from terminals 8 and 9 on a separate secondary winding of transformer T3. Resistor R94 decouples the tube heaters from the B-plus voltage. Capacitors C30 and C31 bypass noise frequencies in the plate circuits of tubes V3 and V4 to ground. A separate winding on transformer T5 develops 6.3 volts ac between terminals 10 and 12, with center tap terminal 11 grounded, and delivers this voltage to terminals 3 and 5 of terminal board TB4.

# Section V. THEORY OF LEVEL CONTROL AND PLATE SUPPLY

## 167. General

The LEVEL CONTROL & PLATE SUPPLY performs two dissimilar functions in the telegraph transmitter group. The level control section amplifies the signals from the SUBGROUP MODULATOR to the required power level for transmission. The plate supply section furnishes B-plus and heater voltages for the level control section and also furnishes B-plus voltage to the transmitters.

## 168. LEVEL CONTROL AND PLATE SUPPLY, Block Diagram Analysis

(fig. 103)

*a. Level Control Section.* Signals in the range of 425 to 2,975 cps from the SUBGROUP MODULATOR are applied to the INPUT LEVEL ADJUST control AT1, which is a 50-db attenuator adjustable in 1-db steps. Attenuator AT1 controls the signal level at the input of the line amplifier and thereby controls the signal output level of the LEVEL CONTROL & PLATE SUPPLY. The signals next encounter AMPLIFIER IN USE switch S1 which routes them to amplifier A (line amplifier AR1) or amplifier B (line amplifier AR2), depending on whether the switch is in the A or B position. The line amplifiers each have a fixed gain of 50-db. The amplifier in use raises the level of the signals to the required transmission power level and delivers them to the LEVEL CONTROL & PLATE SUPPLY output after which they are fed to the 3KC SEND BAND TEST PANEL in cabinet 1 of the transmitting terminal.

*b. Plate Supply Section.* Regulated power at 230 volts ac is applied to power supply A (plate supply PS1) and power supply B (plate supply

PS2). Each power supply normally provides heater and B-plus voltages for one line amplifier and B-plus voltage for 8 transmitter channels. The heater and B-plus circuits of amplifier A and the B-plus circuits of transmitter channels 1 to 8 constitute one load, and the heater and B-plus circuits of amplifier B and the B-plus circuits of transmitter channels 9 to 16 constitute a second load. Each load can be switched to power supply A or power supply B; therefore, if one power supply fails, both loads may be carried by the remaining supply. When CHANNELS 1–8 & AMPL A ON POWER SUPPLY switch S2 is in the A position, power supply A furnishes power to the indicated load; in the B position, power is furnished by power supply B. When CHANNELS 9–16 & AMPL B ON POWER SUPPLY switch S3 is in the B position, power supply B furnishes power to the indicated load; in the A position, power is furnished by power supply A. Switch S2 is normally set in the A position and switch S3 in the B position so that the two power supplies are equally loaded.

*Figure 103. LEVEL CONTROL & PLATE SUPPLY, block diagram.*

(Contained in separate envelope)

## 169. LEVEL CONTROL & PLATE SUPPLY, Schematic Diagram Analysis

(fig. 104)

Figure 104 is a schematic diagram of the LEVEL CONTROL & PLATE SUPPLY.

*a. Level Control Circuits.* Input signals for the level controls circuits are applied to input terminals A and B of connector J18 and pass through the INPUT LINE jacks J1 and J2, and INPUT EQUIP jacks J3 and J4 to input transformer T4 at primary terminals 3 and 4. The INPUT MONITOR jacks J5 and J6 are bridged across the signal circuit following the INPUT EQUIP jacks. From transformer T4 secondary terminals 1 and 2, the signals pass through LEVEL ADJUST control AT1 and are applied to terminals 5 and 2 of AMPLIFIER IN USE switch S1, a two-position, four-segment rotary switch. The LEVEL ADJUST control permits the gain of the level control circuit to be varied between 0 and 50 db in 1-db steps. When switch S1 is in the A position, terminal 5 of section 1 connects to terminal 4, and terminal 2 connects to terminal 1, thereby routing the signals to amplifier A (AR1) at terminals 1 and 2 of terminal board TB1. Signals from the output of amplifier A at terminals 3 and 4 of terminal board TB1 are applied to section 2 of switch S1 at terminals 1 and 4 which connect respectively to terminals 2 and 5. When switch S1 is in the B position, terminal 5 of section 1 connects to terminal 6, and terminal 2 connects to terminal 3, thereby routing the input signals to amplifier B (AR2) at terminals 1 and 2 of terminal board TB1. Signals from the output of amplifier B at terminals 3 and 4 of terminal board TB1 are applied to section 2 of switch S1 at terminals 3 and 6 which connect, respectively, to terminals 2 and 5. Signals from terminals 2 and 5 of section 2, switch S1, pass through the OUTPUT EQUIP jacks J13 and J14 and OUTPUT LINE jacks J15 and J16 to putput terminals C and D of connector J18. The OUTPUT MONITOR jacks J11 and J12 are bridged across the signal circuit following jacks J15 and J16. The unused amplifier is made available for use as a spare by connecting jacks J7 and J8 to its input and jacks J9 and J10 to its output through switch S1. When switch S1 is in the A position, SPARE AMPL INPUT jacks J7 and J8 are connected to the input of amplifier B. Jack J7 connects through section 1 switch terminals 8 and 7 to terminal 1 of terminal board TG1, and jack J8 through switch terminals 11 and 10 to terminal 2 of terminal board TB1. The output of amplifier B connects through section 2 of the switch to SPARE AMPL OUTPUT jacks J9 and J10. Terminal 3 of terminal board TB1 connects through switch terminals 10 and 11 to jack J9, and terminal 4 connects through switch terminals 7 and 8 to jack 10. When switch S1 is in the B position, SPARE AMPL INPUT jacks J7 and J8 are connected to the input of amplifier A. Jack J7 connects through section 1 switch terminals 8 and 9 to terminal 1 on terminal board TB1. Jack J8 connects through switch terminals 11 and 12 to terminal 2 of terminal board TB1. The output of amplifier A connects through section 2 of the switch to SPARE AMPL OUTPUT jacks J9 and J10. Terminal 3 of terminal board TB1 connects through switch terminals 11 and 12 to jack J9. Terminal 4 of terminal board TB1 connects through switch terminals 8 and 9 to jack 10.

*b. Plate Supply Circuits.* Input power at 230 volts ac regulated, 50 or 60 cps, enters at connector J17 and is applied to the input of plate supply PS1 (power supply A) and plate supply PS2 (power supply B) through fuses F3 through F6. PLATE SUPPLY A BLOWN FUSE INDICATORS I 3 and I 4 are bridged across fuses F3 and F4.

PLATE SUPPLY B BLOWN FUSE INDICATORS I 5 and I 6 are bridged across fuses F5 and F6. The input power connects to each plate supply at terminals 1 and 4 of transformer T3 with terminals 2 and 3 strapped together. Plate supplies PS1 and PS2 are identical with plate supply PS1 in the SUBGROUP MODULATOR (par. 166). Each plate supply provides a 6.3-volt ac output between terminals 3 and 5 of terminal board TB4, and an output of 200-volt B-plus at terminal 1 when terminal 2 is grounded. Diodes CR1 and CR2 and indicator lamps I 7 and I 8 are arranged to indicate failure of either plate supply. When the B-plus from plate supply A fails, a small current flows through the failure indicator circuits from terminal 1 of terminal board TB4 on plate supply B to ground inside failed plate supply A. The current passes through diode CR2 in the conducting direction, thereby shorting out indicator lamp I 8. Diode CR1 is reversed with respect to diode CR2 and will not conduct; this forces the current to flow through PLATE SUPPLY A FAILURE indicator lamp I 7, causing it to glow. Similarly when plate supply B fails, the current flows from plate supply A through diode CR1 and causes PLATE SUPPLY B FAILURE indicator lamp I 8 to glow. When the B-plus voltage from both plate supplies is normal, no voltage exists across the failure indicator circuits and both indicator lamps are extinguished. The 6.3-volt ac and B-plus output of power supply A is applied to CHANNELS 1–8 and AMPL A ON POWER SUPPLY switch S2, and from power supply B to CHANNELS 9–16 and AMPL B on POWER SUPPLY switch S3. The output of either power supply A or power supply B may be routed to amplifier A and transmitter channels 1 to 8 or to amplifier B and transmitter channels 9 to 16, by means of switch S2, and switch S3. Switch S2, in the A position, applies 6.3 volts ac from power supply A to terminals 6 and 7 on terminal board TB1 of amplifier A, by way of switch terminal pairs 4–5 and 7–8. The B-plus voltage from power supply A is applied through switch terminals 1 and 2 and fuse F1, bridged by AMPL A BLOWN FUSE INDICATOR lamp, I 1, to terminal 5 on terminal board TB1 of amplifier A. The B-plus voltage from switch terminal 2 is also applied through terminal E of connector J18 to transmitter channels 1 through 8. Switch S2, in the B position, applies 6.3 volts ac from power supply B through switch terminal pairs 6–5 and 9–8 to amplifier A. The B-plus voltage from power supply B is applied to amplifier A and transmitter channels 1 through 8 by way of switch terminals 3 and 2. Switch S3, in the B position, applies 6.3 volts ac from power supply B to terminals 6 and 7 on terminal board TB1 of amplifier B by way of switch terminal pairs 9–8 and 6–5. The B-plus voltage from power supply B is applied through switch terminals 3 and 2 and fuse F2, bridged by AMPL B BLOWN FUSE INDICATOR I 2, to terminal 5 on terminal board TB1 of amplifier B. The B-plus voltage from switch terminal 2 is also applied through terminal F of connector J18 to transmitter channels 9 through 16. Switch S3, in the A position, applies 6.3 volts ac from power supply A through switch terminal pairs 7–8 and 4–5 to amplifier B. The B-plus voltage from power supply A is applied to amplifier B and transmitter channels 9 through 16 by way of switch terminals 1 and 2. When switches S2 and S3 are both in the A position or both in the B position, all power is furnished by the corresponding power supply.

*Figure 104. LEVER CONTROL & PLATE SUPPLY, schematic diagram.*

(Contained in separate envelope)

## 170. LEVEL CONTROL & PLATE SUPPLY, Line Amplifier, Block Diagram Analysis

(fig. 105)

The line amplifier is a three-stage amplifier with a fixed 50-db gain in the 300- to 6,000-cps frequency range and a maximum power output of plus 22 dbm. The signals enter the line amplifier through input transformer T1 and are delivered to first amplifier stage V1A. The amplified output of this stage is fed through an interstage network consisting of resistors R5 and R6 and capacitor C3 to the second amplifier V1B. The output of the second amplifier is applied to the third amplifier V2 through another interstage network made up of resistors R9, R10, and R13 and capacitors C4, C5, and C6. This network attenuates frequencies above and below the 300- to 6,000-cps pass band of the line amplifier. The amplified signals from tube V2 leave the line amplifier through output transformer T2. There are two negative feedback paths from the third amplifier stage V2 back to the first amplifier stage V1A. A voltage feedback network, consisting of resistors R2 and R3 and capacitor C2, and a current feed-

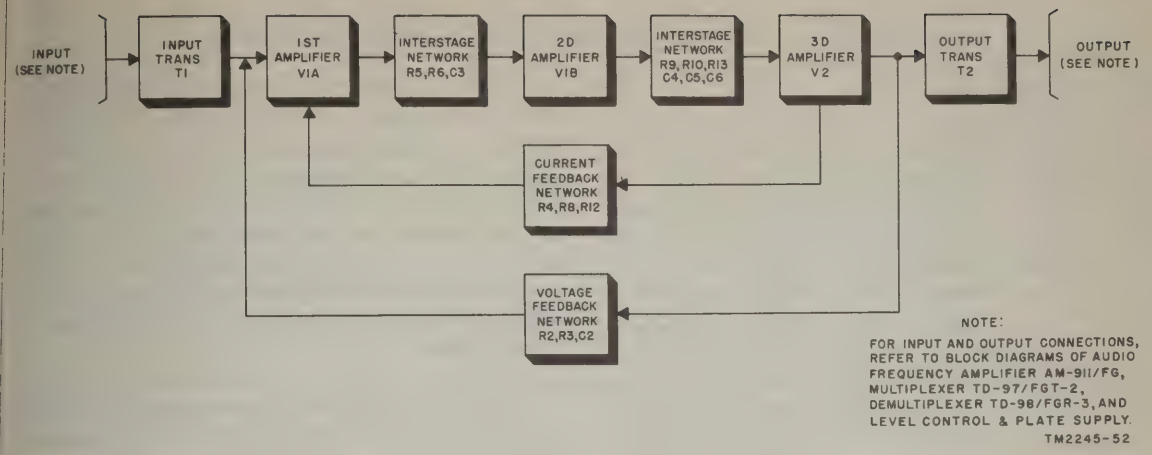

INPUT (SEE NOTE)
INPUT TRANS T1
1ST AMPLIFIER V1A
INTERSTAGE NETWORK R5,R6,C3
2D AMPLIFIER V1B
INTERSTAGE NETWORK R9,R10,R13 C4,C5,C6
3D AMPLIFIER V2
OUTPUT TRANS T2
OUTPUT (SEE NOTE)
CURRENT FEEDBACK NETWORK R4,R8,R12
VOLTAGE FEEDBACK NETWORK R2,R3,C2
NOTE:
FOR INPUT AND OUTPUT CONNECTIONS, REFER TO BLOCK DIAGRAMS OF AUDIO FREQUENCY AMPLIFIER AM-911/FG, MULTIPLEXER TD-97/FGT-2, DEMULTIPLEXER TD-98/FGR-3, AND LEVEL CONTROL & PLATE SUPPLY.
TM2245-52

*Figure 105. Level control & plate supply, line amplifier, block diagram.*

back network, composed of resistors R4, R8, and R12, are used to stabilize amplifier gain and reduce distortion.

## 171. LEVEL CONTROL & PLATE SUPPLY, Line Amplifier, Schematic Diagram Analysis

(fig. 106)

Signals for the line amplifier input enter at terminals 1 and 2 of terminal board TB1 and pass to terminals 1 and 2 of input transformer T1. Transformer T1 is a step-up transformer with a 600-ohm input impedance and a 6,000-ohm output impedance. The output voltage from terminals 3 and 4 of transformer T1 is applied across terminating resistor R1 to the grid of the first amplifier V1A, which is one-half of a type 5751 twin triode. Cathode bias is provided by resistor R4. The plate load resistor for the stage is resistor R5. The signals from the plate of amplifier V1A are impressed on the grid of the second amplifier stage V1B through coupling capacitor C3. Amplifier V1B is the second half of the type 5751 twin triode. Resistor R6 is the grid resistor. Cathode bias is supplied by resistor R7 bypassed by capacitor C1B. The plate load resistor for this stage is resistor R9. Plate decoupling for the first and second amplifier stages is provided by resistor R14 and capacitor C1A. The signals at the plate of amplifier V1B are applied to the grid of third amplifier V2 (a triode-connected type 6AQ5W pentode), through an interstage coupling network consisting of capacitors C4, C5, and C6 and resistors R9, R10, and R13. Resistor R11 is inserted between the plate and screen of tube V2 to prevent parasitic oscillations. Capacitor C5 is the interstage coupling capacitor. Capacitor C4 bypasses to ground frequencies above the 300- to 6,000-cps band. The high series impedance presented by the shaping network made up of resistor R10 and capacitor C6 attenuates frequencies below the band. The output of amplifier V1B is applied to the control grid of amplifier V2 across grid resistor R13. The amplified signals from the plate of tube V2 pass to the primary of the line amplifier output transformer T2 at terminals 1 and 4. Transformer T2 has a 5,000-ohm to 600-ohm impedance ratio which matches the plate impedance of amplifier V2 and provides a 600-ohm balanced output. The output signals taken from the secondary at terminals 5 and 6 arrive at the line amplifier output at terminals 3 and 4 on terminal board TB1. Two feedback paths provide negative feedback. Current feedback between the third and first amplifier stages is provided by the common connection of cathode bias resistors R4 and R12, through unbypassed resistor R8 to ground. A small amount of the output voltage of amplifier V2 is taken from the plate of this tube and fed back to the grid of amplifier V1A through blocking capacitor C2 and the voltage divider made up of resistors R2 and R3. Voltage for the heaters in tubes V1 and V2 at 6.3 volts ac is brought into the line amplifier at terminals 6 and 7 of terminal board TB1. The B-plus 200-volt dc supply is brought in at terminal 5, and terminal 8 is grounded.

*Figure 106. LEVEL CONTROL & PLATE SUPPLY, line amplifier, schematic diagram.*

(Contained in separate envelope)

## 172. General

The A path diversity signals to the telegraph receiver group are applied to SUBGROUP DEMODULATOR A, and the B path signals to SUBGROUP DEMODULATOR B (figs. 252 and 253). The SUBGROUP DEMODULATOR accepts signals containing 16 telegraph channels in the frequency range of 425 to 2,975 cps. The eight even-numbered channels occupy the 425- to 1,615-cps portion of the range and the eight odd-numbered channels, the 1,785- to 2,975-cps portion. The 16 channels pass through the direct path of the SUBGROUP DEMODULATOR to a group of odd-numbered channel receivers which accept the frequencies in the eight odd-numbered channels and reject frequencies in the even-numbered channels. The 16 channels also pass through the translated path of the SUBGROUP DEMODULATOR and emerge inverted in frequency so that the odd-numbered channels occupy the 425- to 1,615-cps range and the even-numbered channels, the 1,785- to 2,975-cps range. These signals are applied to a group of even-numbered channel receivers which accept frequencies in the eight even-numbered channels and reject frequencies in the eight odd-numbered channels. The frequency translation of the even-numbered channels in the translated path is accomplished by two stages of modulation as shown in the frequency translation chart (fig. 107). The first stage of modulation, using a 9,690-cps carrier inverts and shifts the signals to a frequency band extending from 8,075 to 9,265 cps. The second stage of modulation, using a 6,290-cps carrier, shifts these signals to the desired frequency range from 1,785 to 2,975 cps. Frequency translation is accomplished by means of suppressed carrier modulation and single-sideband transmission.

*Figure 107. SUB GROUP DEMODULATOR, frequency, translation chart.*

(Contained in separate envelope)

## 173. SUBGROUP DEMODULATOR, Block Diagram Analysis

(fig. 108)

The signal paths for the SUBGROUP DEMODULATOR are shown in the block diagram. For a detailed analysis of the SUBGROUP DEMODULATOR, refer to paragraph 174 and the schematic diagram (fig. 109).

*a. Direct Path.* Signals in the frequency range of 425 to 2,975 cps enter the SUBGROUP DEMODULATOR and are applied to input network Z3. In the input network, signals for the direct path are obtained from one branch of the branching network and continue to the direct path output. The input signals, unchanged in frequency, are all present at the direct path output. The desired 1,785- to 2,975-cps signals for the odd-numbered channel receivers are accepted by the channel filters in the inputs of the receiver circuits which follow.

*b. Translated Path.* Signals in the frequency range of 425 to 2,975 for the translated path of the SUBGROUP DEMODULATOR are obtained from a second branch of the branching network and are applied to the translated path through a 14-db pad to converter Z2. The pad attenuates the signal to the proper level for the converter. In the converter, the input signals modulate a 9,690-cps carrier generated within the converter. The upper sideband resulting from the modulation process occupies a band of frequencies from 10,115 to 12,665 cps and the lower sideband from 6,715 to 9,265 cps. The carrier and input frequencies are suppressed by balance and do not appear at the converter output. The upper and lower sideband frequencies are fed from the converter to demod filter 1. Demod filter 1 contains an 8-db pad and a band-pass filter. The pad provides a suitable terminating impedance for the output of the converter and acts as a buffer between the converter and the band-pass filter. This filter has a pass band from 6,670 to 9,310 cps that transmits the lower sideband frequencies and rejects the upper sideband. Signals in the lower sideband are fed to the input of modulator Z1 for a second frequency translation. Here the signals modulate a carrier of 6,290 cps generated in carrier supply Y1. The upper sideband resulting from this modulation process extends from 13,005 to 15,555 cps and the lower sideband from 425 to 2,975 cps. Both sidebands are fed to band amplifier AR1 where they are raised to the proper signal level and then applied to the translated path output. Although the output includes both the upper and lower sidebands, only the desired 1,785 to 2,975 cps portion of the lower sideband for the even channel receivers are accepted by the channel filters in the inputs of the receiver circuits that follow. The equalizing networks, included in the input network, compensate the frequency characteristic of the translated path to obtain a flat pass band.

*c. Power Supply.* Plate supply PS1 furnishes the heater voltage and B-plus voltage required

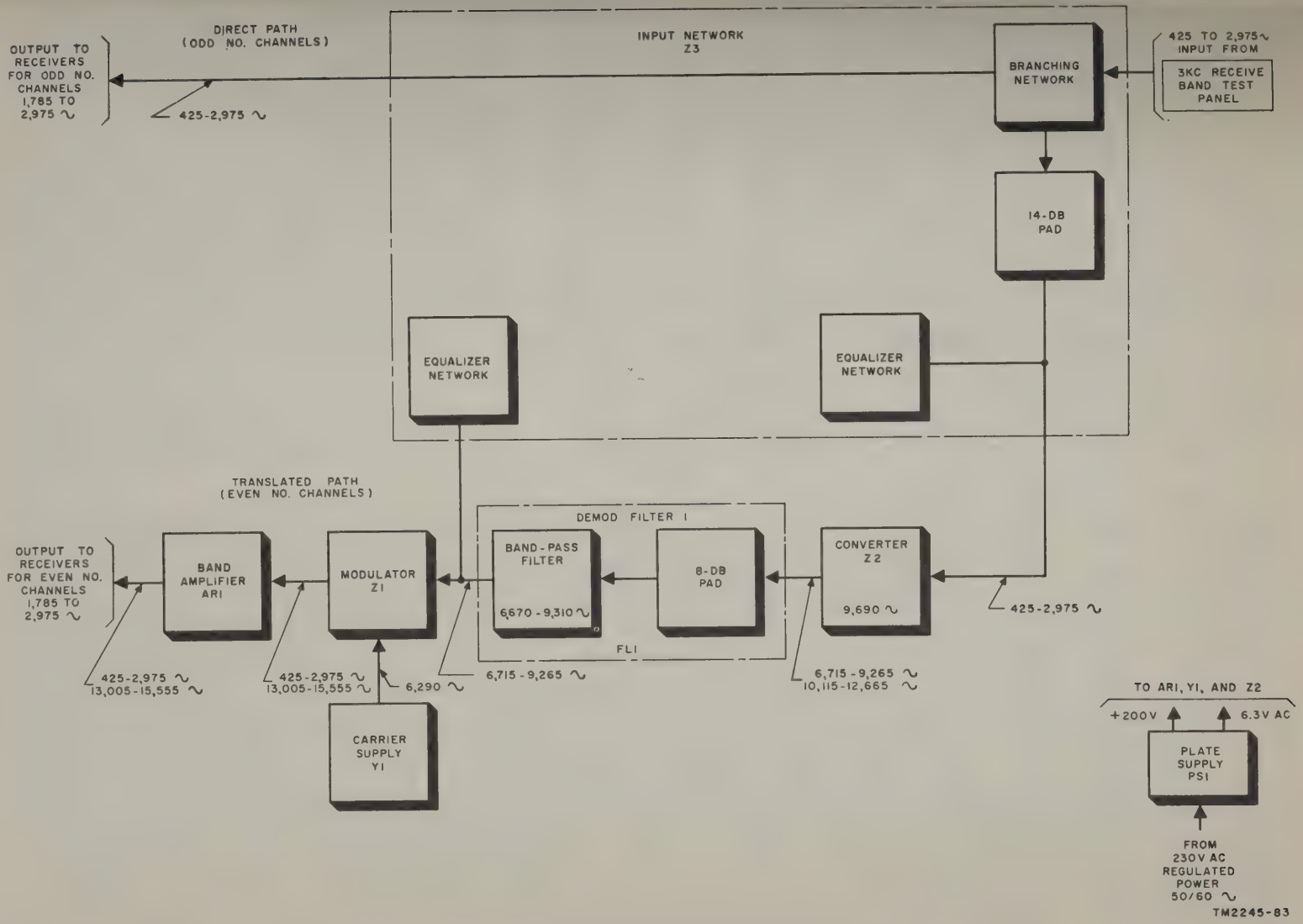



*Figure 108. SUBGROUP DEMODULATOR, block diagram.*

for the operation of converter Z2, carrier supply Y1, and band amplifier AR1 of the SUBGROUP DEMODULATOR. Input power for the plate supply is 230 volts ac, regulated, at 50 or 60 cps. Its output provides a B-plus voltage of 200 volts dc and a heater voltage of 6.3 volts ac.

## 174. SUBGROUP DEMODULATOR, Schematic Diagram Analysis

(fig. 109)

The signal paths of the SUBGROUP DEMODULATOR are shown in detail on the schematic diagram (fig. 109).

*a. Direct Path.* Signals for the SUBGROUP DEMODULATOR enter at terminals A and B of connector J23. From here the signals are applied in turn to INPUT LINE jacks J19 and J20, INPUT EQUIP jacks J17 and J18, and the input network (par. 178). INPUT MONITOR jacks J21 and J22 are bridged across the signal path between the INPUT EQUIP jacks and the input network. The signals enter the input network at terminals 3 and 4 and are transformer-coupled to the input branch of the branching network. The signals from the direct path branch output of the branching network pass through an output transformer and are applied between terminal 5 of the input network and ground at terminal 6. The direct path signals from terminal 5 leave the SUBGROUP DEMODULATOR at terminal G of connector J23.

*b. Translated Path.* Signals from the translated branch output of the branching network are attenuated by a 14-db pad to the proper level for converter Z2 which follows, and leave the input network at terminals 7 and 8. Equalizers in the input network compensate the frequency characteristic of the translated path for uniform response over the signaling band. One equalizer is connected across terminals 7 and 8 of the input network. The other equalizer, between terminals 1 and 2, is bridged across the translated path at the output of demod filter 1. The signals enter converter Z2 at terminals 1 and 2 of terminal board TB7. In the converter (par. 179), the signals modulate a carrier frequency of 9,690 cps generated within the converter. The carrier frequency and the input frequencies are suppressed and the two sidebands that result from the modulation process appear at the converter output at terminals 3 and 4 of terminal board TB7. From here the signals pass to demod filter 1 where they enter by way of terminals 1 and 2. In demod filter 1 the signals pass through an 8-db buffer pad and are applied to a band-pass filter. The band-pass filter transmits the lower sideband and rejects the upper sideband. Signals in the lower sideband leave via terminals 3 and 4 of demod filter 1 and are applied to terminals 1 and 2 on terminal board TB3 of modulator Z1. In the modulator, the signals undergo a second frequency translation, modulating a carrier frequency of 6,290 cps entering at terminals 5 and 6 of terminal board TB3 from terminals 1 and 2 on terminal board TB5 of carrier supply Y1. The carrier and input frequencies are again suppressed. The two sidebands resulting from the modulation process appear at terminals 3 and 4 of terminal board TB3 of the modulator and pass to band amplifier AR1 at terminals 1 and 2 of terminal board TB1. In the band amplifier, the signals in both sidebands are amplified to the level of the signals in the direct path output. The signals leave the amplifier at terminal 3 of terminal board TB1 with terminal 4 grounded, and pass to the translated path output at terminal H of connector J23.

*Figure 109. SUBGROUP DEMODULATOR, schematic diagram.*

(Contained in separate envelope)

## 175. SUBGROUP DEMODULATOR, Band Amplifier, Block Diagram Analysis

(fig. 110)

The band amplifier is a three-stage amplifier with a fixed 23-db voltage gain in the 1,700- to 3,100-cps frequency range and a maximum power output of +19 dbm. The signals are delivered to first amplifier stage V1A. The amplified output of this stage is fed through an interstage network consisting of resistors R4 and R5 and capacitor C2 to the second amplifier V1B. The output of the second amplifier is applied to third amplifier V2 through another interstage network made up of resistors R7 through R10 and capacitors C3, C4, and C5. This network attenuates frequencies above and below the 1,700- to 3,100-cps pass band of the amplifier. The amplified signals from tube V2 leave the band amplifier through output transformer T1. There are two negative feedback paths from third amplifier stage V2 back to first amplifier stage V1A. A voltage feedback network, consisting of resistors R2 and R3 and capacitors C1 and C6; and a current feedback network, composed of resistors R11 and R12, are

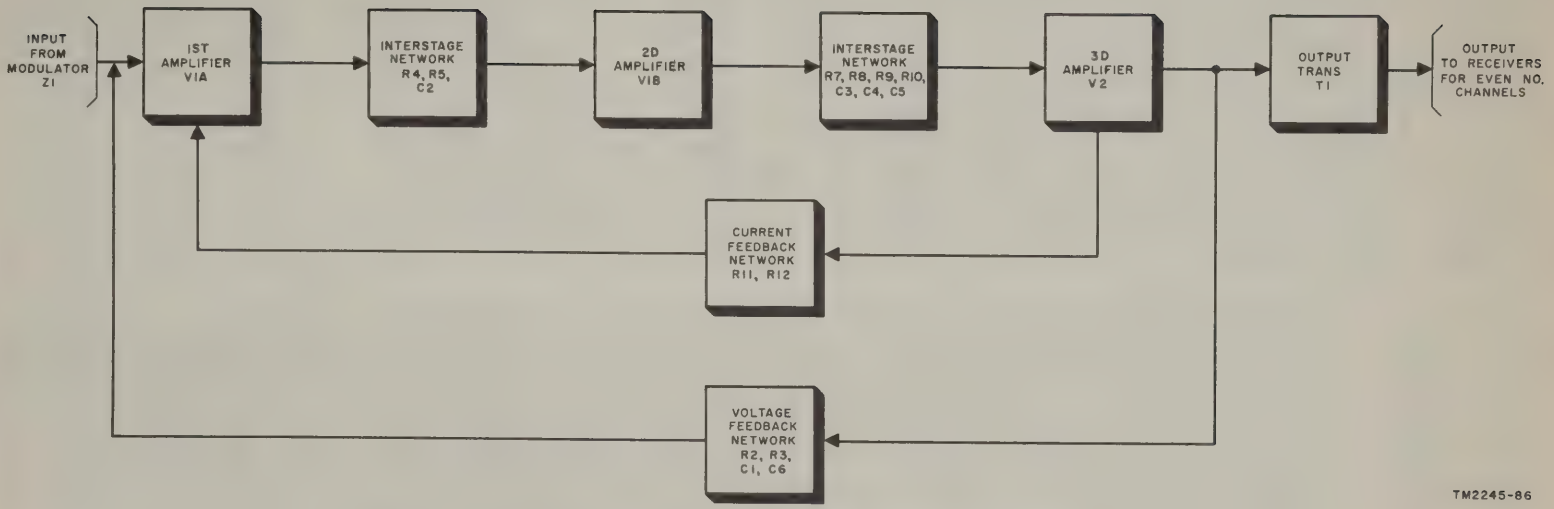

INPUT FROM MODULATOR Z1
1ST AMPLIFIER V1A
INTERSTAGE NETWORK R4, R5, C2
2D AMPLIFIER V1B
INTERSTAGE NETWORK R7, R8, R9, R10, C3, C4, C5
3D AMPLIFIER V2
OUTPUT TRANS T1
OUTPUT TO RECEIVERS FOR EVEN NO. CHANNELS
CURRENT FEEDBACK NETWORK R11, R12
VOLTAGE FEEDBACK NETWORK R2, R3, C1, C6
TM2245-86

*Figure 110. SUBGROUP DEMODULATOR, band amplifier, block diagram.*

used to stabilize amplifier gain and reduce distortion.

## 176. SUBGROUP DEMODULATOR, Band Amplifier, Schematic Diagram Analysis

(fig. 111)

Signals for the band amplifier input enter at terminals 1 and 2 of terminal board TB1. The signal voltage is applied across resistor R1 to the grid of first amplifier V1A. Resistor R1 is a terminating resistor for the preceding modulator circuit (par. 164). Cathode bias is provided by resistor R12. The plate load resistor for the stage is resistor R4. The signals from the plate of amplifier V1A are impressed on the grid of second amplifier stage V1B through coupling capacitor C2. Resistor R5 is the grid resistor. Cathode bias is provided by resistor R6. The plate load resistor for this stage is resistor R7. The signals at the plate of amplifier V1B are applied to third amplifier V2, a triode-connected type 6AQ5W pentode, through an interstage coupling network consisting of capacitors C3, C4, and C5 and resistors R8 through R10. Capacitor C3 is the interstage coupling capacitor. Capacitor C5 and resistor R9 make up a high-frequency shaping network bridging the signal path, and capacitor C4 and resistor R8 make up a low-frequency shaping network in series with the path. These networks are used to attenuate frequencies above and below the pass band of the amplifier. The output of amplifier V1B is applied to the control grid of amplifier V2 across grid resistor R10. Resistor R13 is inserted between the plate and screen of amplifier V2 to prevent parasitic oscillations. Cathode bias is provided by resistor R11 in series with resistor R12. The amplified signals from the plate of V2 pass to the primary of the band amplifier output transformer T1 at terminals 1 and 4. Transformer T1 has a 5,000-ohm to 600-ohm impedance ratio which matches the plate impedance of amplifier V1 and provides a 600-ohm output. The output signals taken from the secondary at terminals 5 and 6 arrive at the band amplifier output at terminals 3 and 4 on terminal board TB1. Two feedback paths provide negative feedback. A current feedback path between the third and first amplifier stages is obtained through resistor R11 and resistor R12 unbypassed to ground. A voltage feedback path from the plate of tube V2 to the grid of amplifier V1A is obtained through blocking capacitor C1 and the voltage divider made up of resistors R2 and R3. Capacitor C6 and resistor R3 form a shaping network which shapes the frequency response of the feedback loop for frequencies above the pass band. Voltage for the heaters in tubes V1 and V2, at 6.3 volts ac, is brought into the band amplifier at terminals 6 and 7 of terminal board TB1. The B-plus 200-volt dc supply is brought in at terminal 5, and terminal 8 is grounded.

*Figure 111. SUBGROUP DEMODULATOR, band amplifier, schematic diagram.*

(Contained in separate envelope)

## 177. SUBGROUP DEMODULATOR, Theory of Demod Filter 1

(fig. 112)

Demod filter is a hermetically sealed unit, containing an 8-db pad and a band-pass filter, used in the translated path of the SUBGROUP DEMODULATOR. Demod filter 1 accepts the output of the converter at terminals 1 and 2. The 8-db pad serves as a terminating impedance for the converter. The band-pass filter passes frequencies in the 6,670- to 9,310-cps range and rejects frequencies above and below this range.

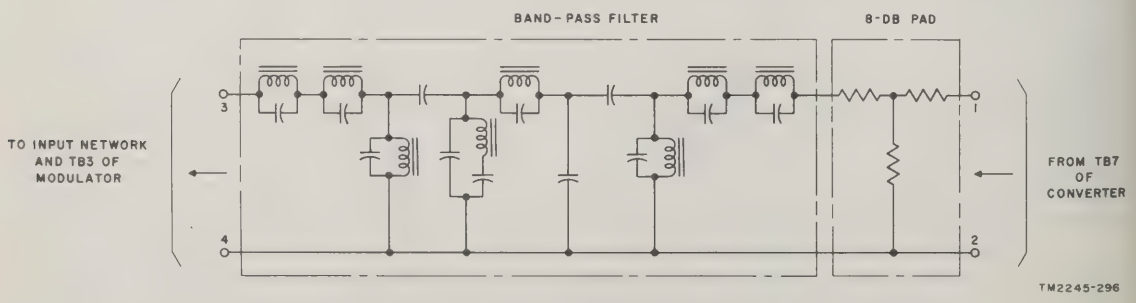



*Figure 112. SUBGROUP DEMODULATOR, demod filter 1, schematic diagram.*

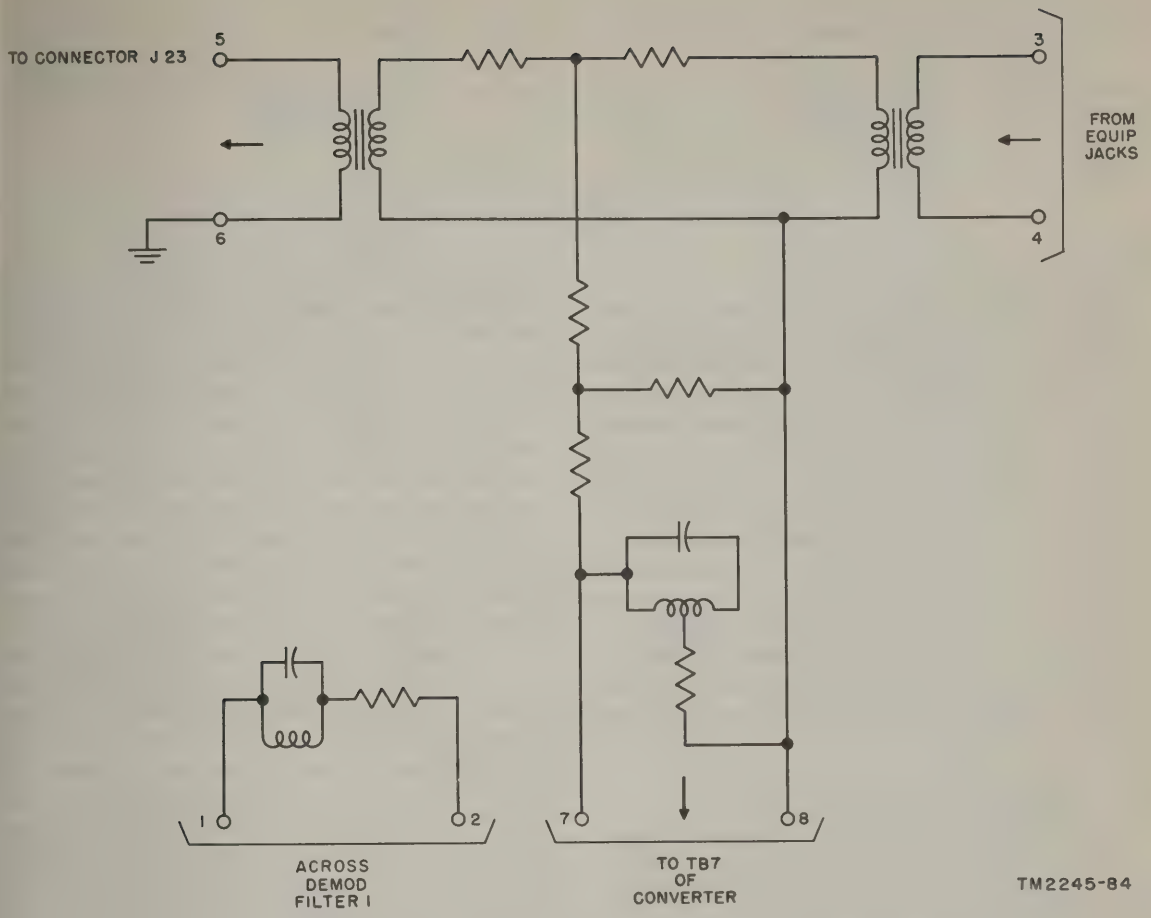



*Figure 113. SUBGROUP DEMODULATOR, input network, schematic diagram.*

The signals are passed on to the modulator from terminals 3 and 4. Figure 112 is a schematic diagram showing the internal configuration of demod filter 1.

## 178. SUBGROUP DEMODULATOR, Theory of Input Network

(fig. 113)

The input network is a hermetically sealed unit lying partly in each path of the SUBGROUP DEMODULATOR. It contains input and output transformers, a branching network, a pad, and two equalizer networks. The input transformer and the branching network are common to both paths while the output transformer lies in the direct path only. The pad and both equalizer networks are connected across the translated path. Signals for both paths enter the input network at terminals 3 and 4 and are applied through the input transformer to the input branch of the branching network. The branching network applies the signals to both the direct and translated paths. Direct path signals, from one branch of the branching network, pass through the output transformer and are applied between output terminal 5 of the input network and ground at terminal 6. Translated path signals from the second branch of the branching network are applied through a 14-db pad to the first equalizer network and to output terminals 7 and 8. The second equalizer network, connected between terminal 1 and 2 of the input network, is bridged across the translated signal path at the output of demod filter 1.

### 179. SUBGROUP DEMODULATOR, Theory of Converter, Carrier Supply, Modulator and Plate Supply

The converter, carrier supply, modulator, and plate supply of the SUBGROUP DEMODULATOR are exactly the same as the corresponding subassemblies in the SUBGROUP MODULATOR. The converter is discussed in paragraphs 158 and 159, and the carrier supply in paragraphs 162 and 163. The theory of the modulator is given in paragraph 164 and of the plate supply in paragraph 166.

## Section VII. THEORY OF RECEIVER

### 180. General

The receiver selects two diversity carrier signals of the same frequency from the output signals of SUBGROUP DEMODULATORS A and B, and prepares them for combining in an associated combiner (figs. 250 and 251). Electronic control circuits in the receiver modify the two diversity signals so that the stronger received signal is maintained at a fixed output level, and the voltage ratio of the receiver output signals is made equal to the square of the ratio of the input signals. Adjustable delay networks in the receiver compensate for delay differences in the diversity channels introduced by system equipment. There are 16 receivers in the AN/FGC–29 terminal, the channel designations and frequencies of which are listed in paragraph 11*d*.

### 181. Receiver, Block Diagram Analysis

(fig. 114)

For a more detailed analysis of the receiver, refer to paragraph 182 and the schematic diagram (fig. 255).

*a. Signal Paths.* The input signals for the receiver are obtained from the appropriate receive buses, as determined by the receiver channel number and the particular receiver path. The A path signals are applied to receiver filter FL1 and the B path signals, to receiver filter FL2. Receiver filters FL1 and FL2 are identical bandpass networks which select the diversity carrier signals for the channel from the other channel frequencies present on the A path and B path receive buses. The carrier signals passing through receiving filters FL1 and FL2 are transformed to a high-impedance level and enter delay amplifiers AR1 and AR2, respectively. The delay amplifiers permit the insertion of an adjustable time delay in their respective paths to allow equalization of any delay difference between the diversity signals which may be introduced by system equipment. The delay amplifier also provides for the adjustment of signal levels. The A path and B path signals are next applied to the input of agc amplifiers AR3 and AR4, respectively. These amplifiers and their associated control varistors (CR1, CR2, and CR3, CR4) have interconnected control circuits and operate together, in two-channel diversity, to modify the signal levels. The agc amplifier having the larger input signal automatically adjusts its gain to maintain an essentially constant output level over an input signal fading range of 40 db. The gain of the agc amplifier having the smaller input signal is automatically adjusted so that the voltage ratio of the two output signals of the amplifiers follows the square of the ratio of the two input signals. The signals then pass to the respective A path and B path inputs of an associated combiner where the actual addition of the diversity signals is accomplished. For four-channel diversity operation, the control circuits of two receivers are interconnected by way of their associated combiner so that the four agc amplifiers of the two receivers operate as a unit to square the ratios of the four received signals. The actual addition of the four diversity signals takes place in the associated combiner.

*b. Power Supply.* Plate supply PS1 furnishes the heater voltage and B-plus voltage required for the operation of delay amplifiers AR1 and AR2 and agc amplifiers AR3 and AR4 of the receiver. Plate supply PS1 also furnishes B-plus voltage to the combiner circuits associated with the receiver. Input power for plate supply PS1 is regulated 230 volts ac at 50 or 60 cps. Its output provides a B-plus voltage of 200 volts dc and a heater voltage of 6.3 volts ac.

### 182. Receiver, Schematic Diagram Analysis

(fig. 255)

The signal paths of the receiver are shown in detail on the schematic diagram (fig. 255). The A and B paths are electrically identical; when circuit components bear different reference symbols for the A path and the B, path parentheses are used in the text to indicate the B path.

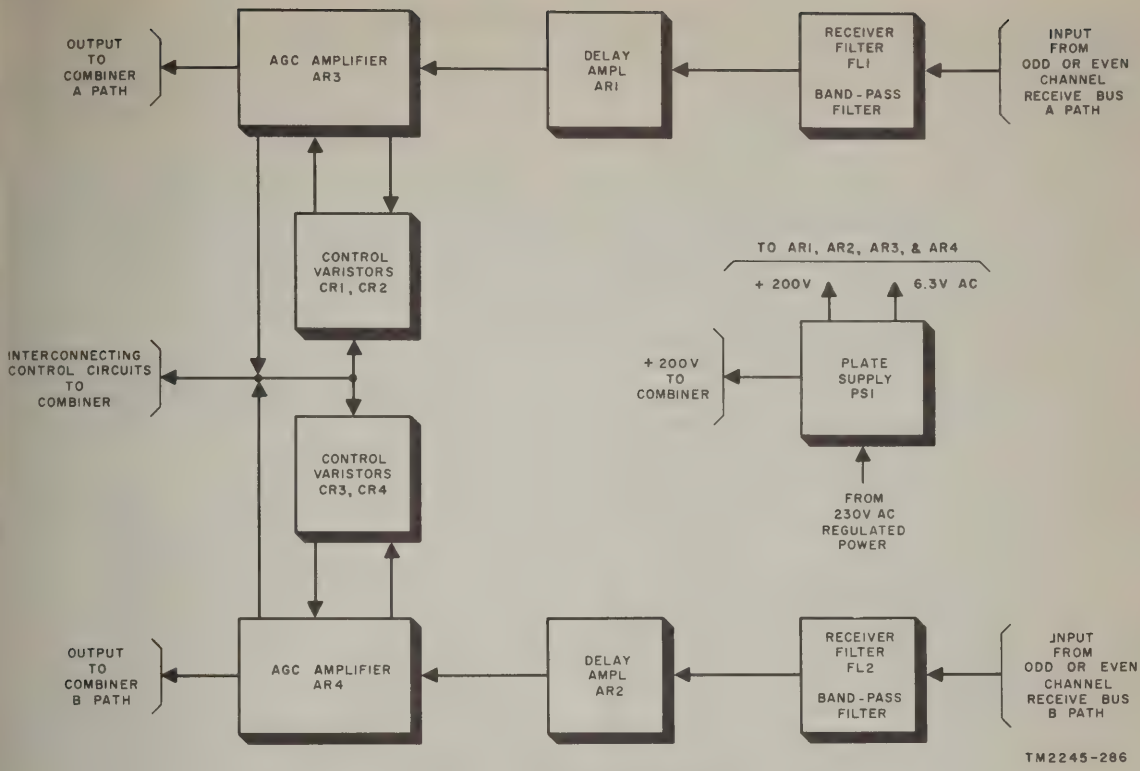

OUTPUT TO COMBINER A PATH
AGC AMPLIFIER AR3
DELAY AMPL AR1
RECEIVER FILTER FL1
BAND-PASS FILTER
INPUT FROM ODD OR EVEN CHANNEL RECEIVE BUS A PATH
CONTROL VARISTORS CR1, CR2
TO AR1, AR2, AR3, & AR4
+ 200V
6.3V AC
INTERCONNECTING CONTROL CIRCUITS TO COMBINER
+ 200V TO COMBINER
PLATE SUPPLY PS1
CONTROL VARISTORS CR3, CR4
FROM 230V AC REGULATED POWER
OUTPUT TO COMBINER B PATH
AGC AMPLIFIER AR4
DELAY AMPL AR2
RECEIVER FILTER FL2
BAND-PASS FILTER
INPUT FROM ODD OR EVEN CHANNEL RECEIVE BUS B PATH
TM2245-286

*Figure 114. Receiver, block diagram.*

*a. Signal Paths.* Signals enter the receiver at terminal G (H) on connector J16 and pass through EQUIP jack J3 (J9) to input terminal 1 of receiver filter FL1 (FL2). Receiver filter FL1 (FL2) is a band-pass network which passes only the signals of its assigned channel and rejects all other frequencies. The output signals on terminal 3 of receiver filter FL1 (FL2) pass through LINE jack J1 (J7) to terminal 1 on terminal board TB5 of delay amplifier AR1 (AR2). Common terminals 2 and 4 on receiver filter FL1 (FL2) and the tip contacts of EQUIP jack J4 (J10) and LINE jack J2 (J8) are tied to the ground side of the signal path. Delay amplifier AR1 (AR2) permits time delay and level adjustments of the signals. The OUTPUT and GRD pin jacks are connected across the signal circuit at the output of the delay amplifier. The signals leaving the delay amplifier on terminal 4 of terminal board TB5 enter agc amplifier AR3 (AR4) on terminal 1 of terminal board TB7. Input signals appearing across MON LEVEL ADJ resistor R10 are applied to MONITOR jack J5 (J11) through terminal 4 of terminal board TB7. MONITOR jack J6 (J12) is the ground side of the monitor circuit. METER jacks J13 and J14 are in the signal and ground sides, respectively, of the meter circuit. METER SWITCH S1 connects METER jack J13 to terminal 9 on terminal board TB7 of agc amplifier AR3 when in the A position and to terminal 9 on terminal board TB7 of agc amplifier AR4 when in the B position. METER SWITCH S1 permits comparison of signal levels in agc amplifiers AR3 and AR4. The output signals at terminal 2 on terminal board TB7 of agc amplifier AR3 (AR4) leave the receiver by way of terminal A (B) on connector J16. Three interconnecting control circuits exist between agc amplifiers AR3 and AR4. These circuits are also connected to terminals D, E, and F of connector J16 where they are indicated on the schematic diagram (fig. 255) as common, control, and reference circuits, respectively.

*b. Power Supply.* The regulated 230-volt, 50- or 60-cycle ac power brought in at connector J15 is applied through fuses F1 and F2 to terminals 4 and 1 of input transformer T3 in plate supply PS1, with terminals 2 and 3 strapped. Fuses F1 and F2 are inserted in each side of the power line to protect the receiver and associated combiner

circuits against overload. BLOWN FUSE INDICATOR lamps I 1 and I 2 are bridged across fuses F1 and F2. Should either fuse blow, the input power will be applied directly across the corresponding neon indicator lamp causing it to glow. The B-plus output of plate supply PS1 appears at terminal 1 of terminal board TB4 and is applied to terminal 3 on terminal board TB5 of delay amplifier AR1 (AR2) and terminal 3 of terminal board TB7 of agc amplifier AR3 (AR4) for the plate circuits of tubes in these units. Plus 200 volts dc is also brought to terminal C on connector J16 for use in the associated combiner. The 6.3-volt ac heater voltages from terminals 3 and 5 of terminal board TB4 is applied to terminals 5 and 6 on terminal board TB5 of delay amplifier AR3 (AR4) and terminals 5 and 6 on terminal board TB7 of agc amplifier AR3 (AR4) for tube heaters in these units.

*c. Jacks and Controls.* A group of three jack pairs in each path of the receiver are used to provide connections to the receiver circuits for testing or monitoring purposes. In each group are two EQUIP jacks, two LINE jacks, and two MONITOR jacks used with cords equipped with twin plugs. The EQUIP jacks for each path permit the introduction of test signals into the input circuit associated with each path. The LINE jacks for each path permit removal of the signals from the associated delay amplifier input and terminate them to ground through resistors R62 (R64) and R63 (R65) in series and allow measurement of the signal level existing across resistor R62 (R64) associated with each path. When in use, these jacks also ground the input circuit of the associated delay amplifier to prevent noise pickup. The MONITOR jacks for each path are used to monitor the signal level entering the associated agc amplifier. The METER jacks and associated METER SWITCH are used to monitor the signal level in either agc amplifier AR3 for the A path or agc amplifier AR4 for the B path. Additional jacks and controls are located internally on the top of the chassis. The OUTPUT and GRD pin jacks in each path permit measurement of the output level of the associated delay amplifier. The LEVEL ADJ control for each path permits adjustment of the delay amplifier input level and the DELAY ADJUST control for each path adjusts the delay of signals through the delay amplifier.

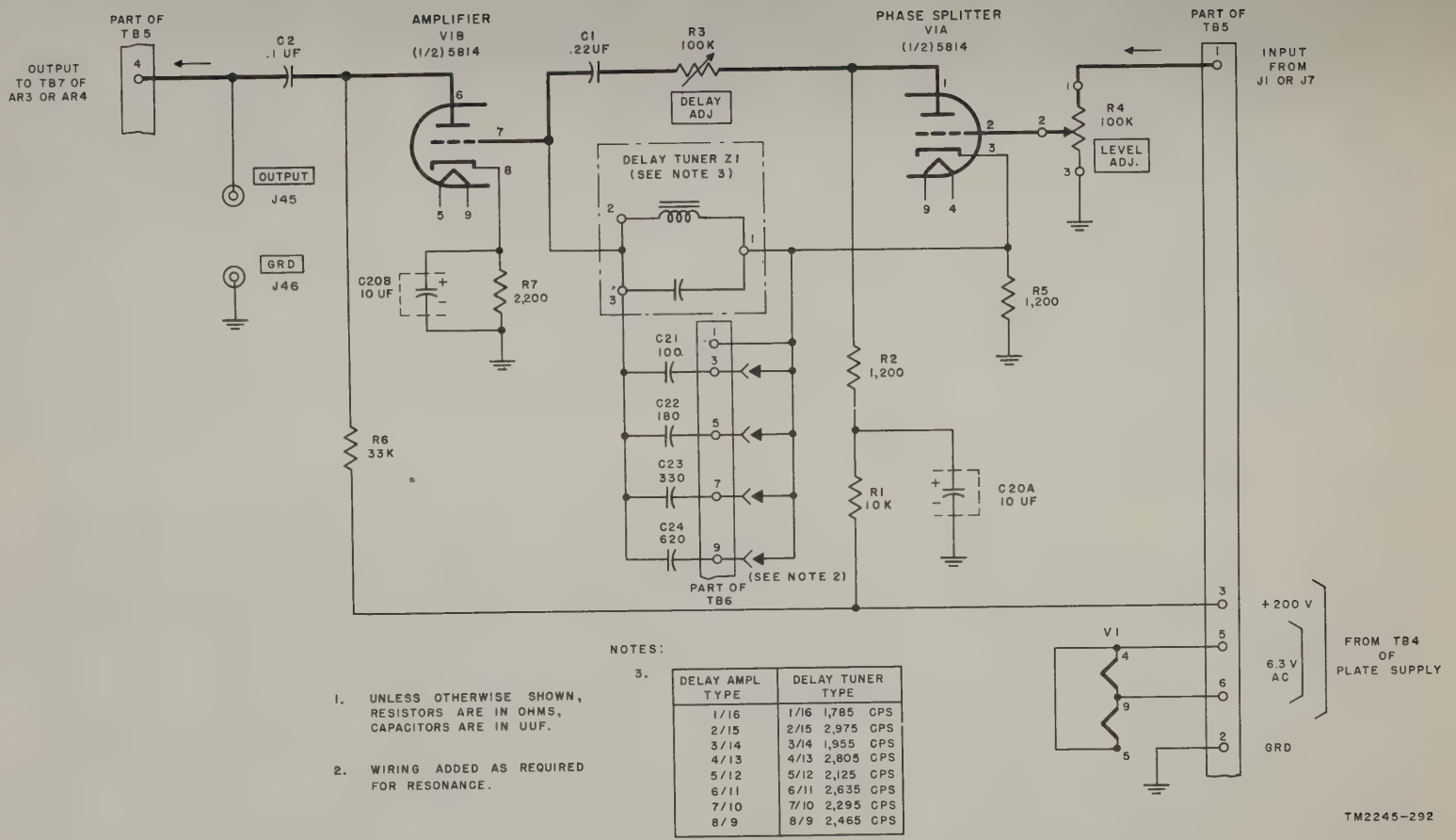
## 183. Receiver, Theory of Delay Amplifier
(figs. 115 and 255)

The circuits of the delay amplifier are shown in detail on the schematic diagram (fig. 115). The delay amplifier is a two-stage amplifier with a maximum signal time delay of approximately 6.5 milliseconds and a maximum voltage gain of 13 db. The AN/FGC–29 terminal uses four each of the delay amplifiers listed in the chart below. Each delay amplifier operates at a specific carrier frequency as determined by its included delay tuner.

| Delay amplifier designation | Delay tuner designation | Channel frequency |
|---|---|---|
| 1/16 | 1/16 | 1, 785 |
| 2/15 | 2/15 | 2, 975 |
| 3/14 | 3/14 | 1, 955 |
| 4/13 | 4/13 | 2, 805 |
| 5/12 | 5/12 | 2, 125 |
| 6/11 | 6/11 | 2, 635 |
| 7/10 | 7/10 | 2, 295 |
| 8/9 | 8/9 | 2, 465 |

*a.* Input signals to the delay amplifier enter at terminal 1 on terminal board TB5 and pass to ground through LEVEL ADJ resistor R4. From the movable arm on resistor R4, the signals are applied to the control grid of phase splitter stage V1A. Cathode bias is provided by resistor R5 which also serves as the cathode load resistor. Resistor R2 is the plate load resistor for the stage. Resistors R2 and R5 are of equal value so that the signals appearing at the plate and cathode of V1A are of equal magnitude but of opposite phase with respect to ground. Resistor R1 and capacitor C20A decouple the signal frequencies from the B-plus supply. Delay tuner Z1, trimmer capacitors C21 through C24, variable resistor R3, and blocking capacitor C1 constitute an adjustable delay network.

*b.* The theory of this network is best explained with reference to figure 116. Capacitors C1 and C20A are omitted on this diagram because their impedances at the signal frequencies are negligible. To simplify the circuit discussion trimmer capacitors C21 through C24 are also omitted. The delay network, in conjunction with phase splitter V1A, forms a bridge network in which resistors R2 and R5 are the two equal fixed resistive arms, resistor R3 is the adjustable resistive arm, and




NOTES:

1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UUF.

2. WIRING ADDED AS REQUIRED FOR RESONANCE.

3.

| DELAY AMPL TYPE | DELAY TUNER TYPE |
|---|---|
| 1/16 | 1/16 1,785 CPS |
| 2/15 | 2/15 2,975 CPS |
| 3/14 | 3/14 1,955 CPS |
| 4/13 | 4/13 2,805 CPS |
| 5/12 | 5/12 2,125 CPS |
| 6/11 | 6/11 2,635 CPS |
| 7/10 | 7/10 2,295 CPS |
| 8/9 | 8/9 2,465 CPS |

*Figure 115. Receiver, delay amplifier, schematic diagram.*

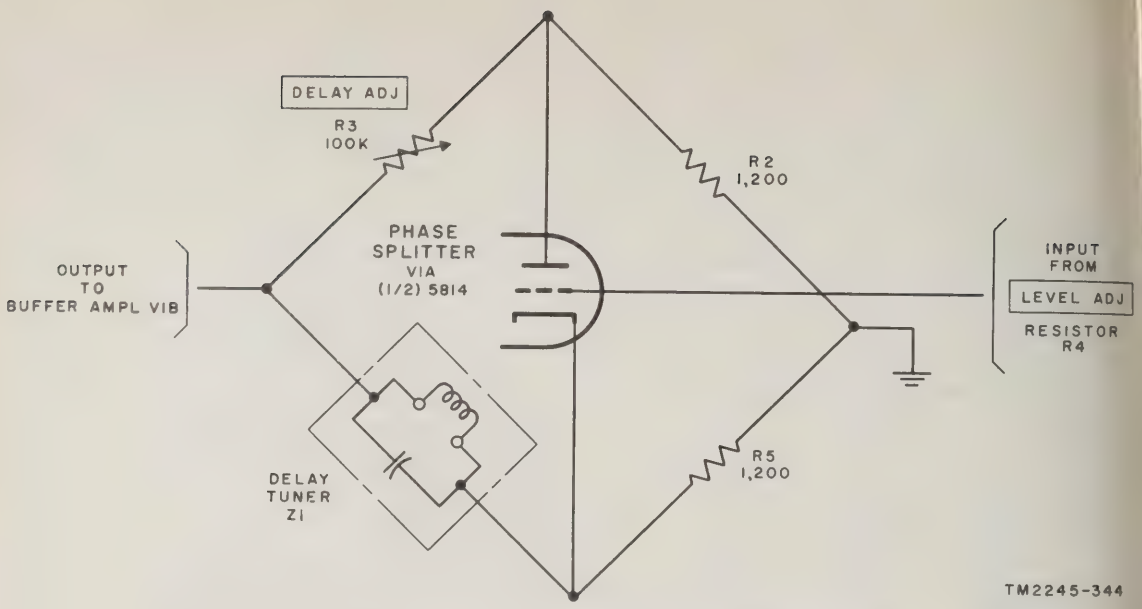



*Figure 116. Delay amplifier, phase-shifting network, simplified schematic diagram.*

delay tuner Z1 is the antiresonant arm tuned to the center frequency of the channel. The bridge is energized by equal and opposite signal voltages existing at the plate and cathode of phase splitter V1A.

(1) When DELAY ADJUST resistor R3 is set for zero resistance, the output signal from the bridge to buffer amplifier V1B is the signal at the plate of V1A, and no time delay is added to the signal path.

(2) When DELAY ADJUST resistor R3 is set for maximum resistance, the phase shift with respect to frequency across the channel frequency band, as measured at the output of the bridge, is at a maximum.

(3) The time delay added to the modulation envelope is proportional to the rate of change of phase with respect to frequency so that maximum signal delay is obtained when resistor R3 is at maximum resistance.

(4) Within the channel frequency band, the phase shift is essentially linear with respect to frequency to avoid distortion of the modulation envelope. Resistor R3 controls the rate of change of phase and consequently the time delay added to the signal.

*c.* Signals from the output of the bridge are applied to the grid of buffer amplifier V1B. Cathode bias is supplied by resistor R7 bypassed by capacitor C20B. Resistor R6 is the plate load resistor for this stage. The output signals on the plate of amplifier V1B pass through coupling capacitor C2 to output terminal 4 on terminal board TB5. Output signals are measured between OUTPUT test jack J45 and GRD test jack J46. Heater voltage of 6.3 volts ac for stages V1A and V1B is brought into the delay amplifier at terminals 5 and 6 on terminal board TB5. The 200-volt B-plus supply enters at terminal 3 on terminal board TB5 with terminal 2 as the ground connection.

## 184. Receiver, Agc Amplifier, Block Diagram Analysis

(figs. 114 and 117)

In each receiver there are two identical agc amplifiers, AR3 and AR4, which control the levels of the A and B path signals. The agc amplifiers are shown on the block diagram (fig. 117) connected for two-channel diversity operation. The theory of the agc amplifier is discussed with reference to signal path A of the receiver. When interconnections between the agc amplifiers occur, they are discussed with reference to both signal paths. There are two circuits in each agc amplifier: the gain control circuit (*a*

below) and the expanding circuit (*b* below). The theory of the two agc amplifiers operating in diversity is discussed in *c* below.

*a. Gain Control Circuit.* The gain control circuit consists of a variolosser, an input amplifier circuit, and a gain control regulating circuit. The function of the gain control circuit is to maintain a practically constant signal output level under radio selective fading conditions which may reduce the input signal 40 db below normal level. This is accomplished by the automatic adjustment of the variolosser attenuation to compensate for the variations in received signal level and thereby hold the signal applied to the input amplifier circuit at a fixed level. The variolosser attenuation is automatically controlled by the gain regulating circuit of the agc amplifier.

(1) The input signals first pass through a variolosser comprising an attenuation network consisting of transformer T1 and T2, resistors R8, R9, and R11 through R14, and control varistors CR1 (CR3) and CR2 (CR4) located on the front panel of the receiver. The control varistors change the loss of the attenuation network to compensate for changing input signal levels so that the signals leaving the variolosser are essentially constant in amplitude.

(2) The attenuated signals enter the three-stage, fixed-gain, input amplifier circuit consisting of amplifier tubes V5A, V5B, and V6A. The input amplifier circuit has a gain of approximately 70 db and is stabilized by negative voltage feedback. There are two outputs from the input amplifier circuit. One, the signal path output, is applied to the expanding circuit and the other is applied to the gain control regulating circuit for automatic adjustment of the variolosser attenuation.

(3) The input signal to the gain control regulating circuit enters first buffer amplifier V7A which is coupled through transformer T4 to the variolosser control rectifier consisting of diodes CR8 and CR9 and capacitor C13. The variolosser control rectifier is a full-wave rectifier of relatively low impedance which furnishes a positive output voltage that is directly proportional to its input signal voltage from transformer T4. The positive output voltage passes through the diode switch (diode CR7 and resistor R39) and enters the feedback shaping network. The feedback shaping network, comprising capacitors C11 and C12 and resistors R36, R37, and R38, is a resistor-capacitor low-pass filter which establishes the proper response time of the gain control circuit and prevents undesired oscillations. The output of the feedback shaping network regulates variolosser control amplifier V6B. This amplifier is a direct-coupled cathode follower stage with a low output impedance which furnishes positive control voltage to the control varistors in the variolosser. The reference voltage network, formed by resistors R15 through R18 and capacitor C3B, applies a constant positive dc voltage to the control varistors which opposes the effect of the positive control voltage from variolosser control amplifier V6B. When the control voltage is absent, the reference voltage biases varistors CR1 (CR3) and CR2 (CR4) in the nonconducting direction and, therefore, maintains the variolosser at minimum attenuation. The magnitude of the fixed reference voltage determines the output level of the input amplifier circuit at which automatic level control action takes place. The reference voltage holds the variolosser at minimum attenuation until the output signal of the input amplifier circuit is large enough to bring the dc output of variolosser control amplifier V6B up to the same voltage. If the input amplifier circuit output now tends to increase, the variolosser control amplifier output becomes larger than the reference voltage and biases the control varistors in the conducting direction. When the varistors conduct, they increase the attenuation of the variolosser by the amount required to maintain the same signal level output from the input amplifier circuit. The variolosser range and sensitivity are sufficient to reduce a 40-db signal level change at the input of the gain control circuit to a 1-db change at the output.

*b. Expanding Circuit.* The expanding circuit delivers an output signal which varies in amplitude in proportion to the square of its input signal amplitude. In terms of decibels, this means the output level change in db is always twice the input level change in db. The output signal of the gain control circuit is applied to the input of second buffer amplifier V7B. The output transformer T5 for this stage supplies a low level output signal for the expander and a high level output for the expander control rectifier. The low level signal is passed to the expander which consists of transformer T6, resistor R52, and diodes CR10 and CR11. The expander control rectifier, consisting of diodes CR12 and CR13, is a full-wave rectifier which develops a positive voltage proportional to the level of its input control signal and applies this voltage to the expander damping network. The expander damping network, consisting of capacitors C19 and C25 and resistors R53 and R54, is a resistor-capacitor low-pass filter which determines the dynamic response time of the expanding circuit. The expander is a variable attenuator circuit which is controlled by the rectified voltage from the expander damping network. When the input signal to the second buffer amplifier decreases, the output of the expander damping network decreases proportionately, thereby increasing the attenuation of the expander. The increase in attenuation is equal to the decrease in signal at the input of the second buffer amplifier both expressed in decibels. When the input to the second buffer amplifier decreases, the input signal to the expander also decreases proportionately. Since the expander input signal is decreased and its attenuation proportionately increased, the expander output signal decrease is twice its input signal decrease when both signals are expressed in decibels. In linear terms, this means the expander output signal varies as the square of its input signal. The expanding signals are applied to the output amplifier circuit consisting of two stages, V8A and V8B. The output amplifier circuit has approximately 40-db gain, and is stabilized by negative voltage feedback. The signals from the output amplifier circuit pass to the associated combiner which follows. The response time of the expanding circuit is sufficiently slow so that rapid changes in the signal level, caused by noise or signaling transients that have not been fully corrected by the gain control circuit, are not expanded by the expanding circuit. Slow level changes caused by radio selective fading are fully expanded.

*c. Diversity Operation.* For optimum diversity performance, the agc amplifiers in the A and B paths of the receiver are required to modify the two diversity signals in the following manner. The output of the agc amplifier having the stronger input signal must be maintained at a constant level. The output of the agc amplifier having the weaker input signal must be reduced so that the ratio of the two output signals follows the square of the ratio of the input signals. These modifications are accomplished in two main steps. First, the gain control circuits of the two agc amplifiers are so interconnected that they always have equal gain, the gain being controlled by the stronger signal. Therefore, the output signals from the two gain control circuits have the same ratio as the two input signals, and the stronger signal output level is held fixed. The input to the expanding circuit in the stronger signal path thereby is held constant, so that the gain of this circuit does not change. Consequently, the signal level at the output of the agc amplifier in the stronger signal path remains constant. Secondly, since the gain of an expanding circuit is proportional to its input signal level (*b* above), the weaker signal receives less amplification in its expanding circuit than the amplification received by the stronger signal in the expanding circuit of the other path. The decrease in gain in the weaker signal path increases the difference between the stronger and weaker signal levels and is of such magnitude as to produce the required ratio between the two signal levels at the output of the agc amplifiers. There are three interconnections between the gain control circuits of the two agc amplifiers. Two of the interconnections, one between the two reference voltages and the other between the variolosser control amplifiers, insure that the variolossers of both paths are actuated by the same control voltage. Therefore, both gain control circuits always have equal amplification and the ratio of the signals at the output of these circuits is the same as the input signal ratio. The third interconnection, between the outputs of the two diode switches, permits the stronger signal to determine the amplification of both gain control circuits. As a result, the output of the stronger signal automatically is held at a fixed level. The diode switch in the path having the stronger signal conducts and biases the diode switch of the other

path to the open condition. This isolates the variolosser control rectifier of the weaker signal path, leaving both paths under control of the stronger signal. When operating in the presence of radio selective fading, the relative amplitudes of the A and B path signals are continually changing in an unpredictable manner so that either path may have the stronger input signal at any given instant. During the intervals when both input signals are of equal amplitude, the agc amplifiers have equal output and both signals contribute equally to the channel output.

*Figure 117. Receiver, agc amplifier, block diagram.*

(Contained in separate envelope)

## 185. Receiver, Agc Amplifier, Schematic Diagram Analysis

(figs. 122 and 255)

The signal and control paths of the agc amplifier are shown in detail on the schematic diagram (fig. 122).

*a. Gain Control Circuit.*

(1) Figure 118 is a simplified schematic diagram of the variolosser circuit. Control varistors CR1 and CR2 associated with A path agc amplifier AR3 and varistors CR3 and CR4 associated B path agc amplifier AR4 are mounted on the front panel of the receiver. Parentheses are used in the text to indicate the B path varistors, otherwise both agc amplifiers in the receiver are identical. The variolosser circuit consists of the attenuation network, comprising transformer T1 and T2 and resistors R8, R9, R11 through R14, and control varistors CR1 (CR3) and CR2 (CR4). Signals from delay amplifier AR1 (AR2) enter the variolosser at terminal 1 of terminal board TB7 and are impressed across primary terminals 1 and 2 of transformer T1 in series with MON LEVEL ADJ resistor R10 to ground. The primary and secondary impedances of the transformer are 20,000 ohms and 5,000 ohms, respectively. The signals from secondary terminals 3 and 4 of transformer T1 pass through resistors R8 and R9 and are impressed across shunting varistor CR1 (CR3) through terminals 15 and 16 of terminal board TB7. That portion of the signals appearing across the varistor then passes through resistors R11 and R12 and is impressed across shunting varistor CR2 (CR4) through terminals 13 and 14 of terminal board TB7. The signals appearing across this varistor are applied to terminals 3 and 4 of transformer T2 through resistors R13 and R14. The variolosser output from secondary terminals 1 and 2 of transformer T2 is fed to the first input amplifier which follows. Each varistor consists of four diodes arranged in a bridge circuit configuration. Terminals 4 and 6 of each varistor are connected across the signal path and terminals 2 and 5 are connected to reference and control voltages, respectively. A fixed positive reference voltage is obtained from the voltage divider network consisting of resistors R15 through R18 and bypass capacitor C3B (fig. 122). This voltage is applied to terminal 2 of varistor CR1 (CR3) and terminal 2 of varistor CR2 (CR4) through terminal 11 of terminal board TB7. A positive variable control voltage from the cathode of variolosser control amplifier V6B is applied to terminal 5 of varistor CR1 (CR3), and terminal 5 of varistor CR2 (CR4), through terminal 10 of terminal TB7. This control voltage is directly proportional to the output signal level of the third input amplifier V6A. When the input signal to the agc amplifier is absent or below the level control range of the amplifier, then the positive control voltage is less than the positive reference voltage. The polarity of terminal 5 on each varistor is then negative with respect to terminal 2, and all varistor diodes are biased in the nonconducting direction so that the effective resistance between terminals 4 and 6 of each varistor becomes extremely high. The corresponding shunting effect of the varistors to signals flowing through the attenuation network is negligible and the variolosser exhibits minimum attentuation. When the input signal level to the agc amplifier is within the correcting range, the positive control voltage becomes greater than the positive reference voltage, so that the polarity of terminal 5 on each varistor becomes positive with respect

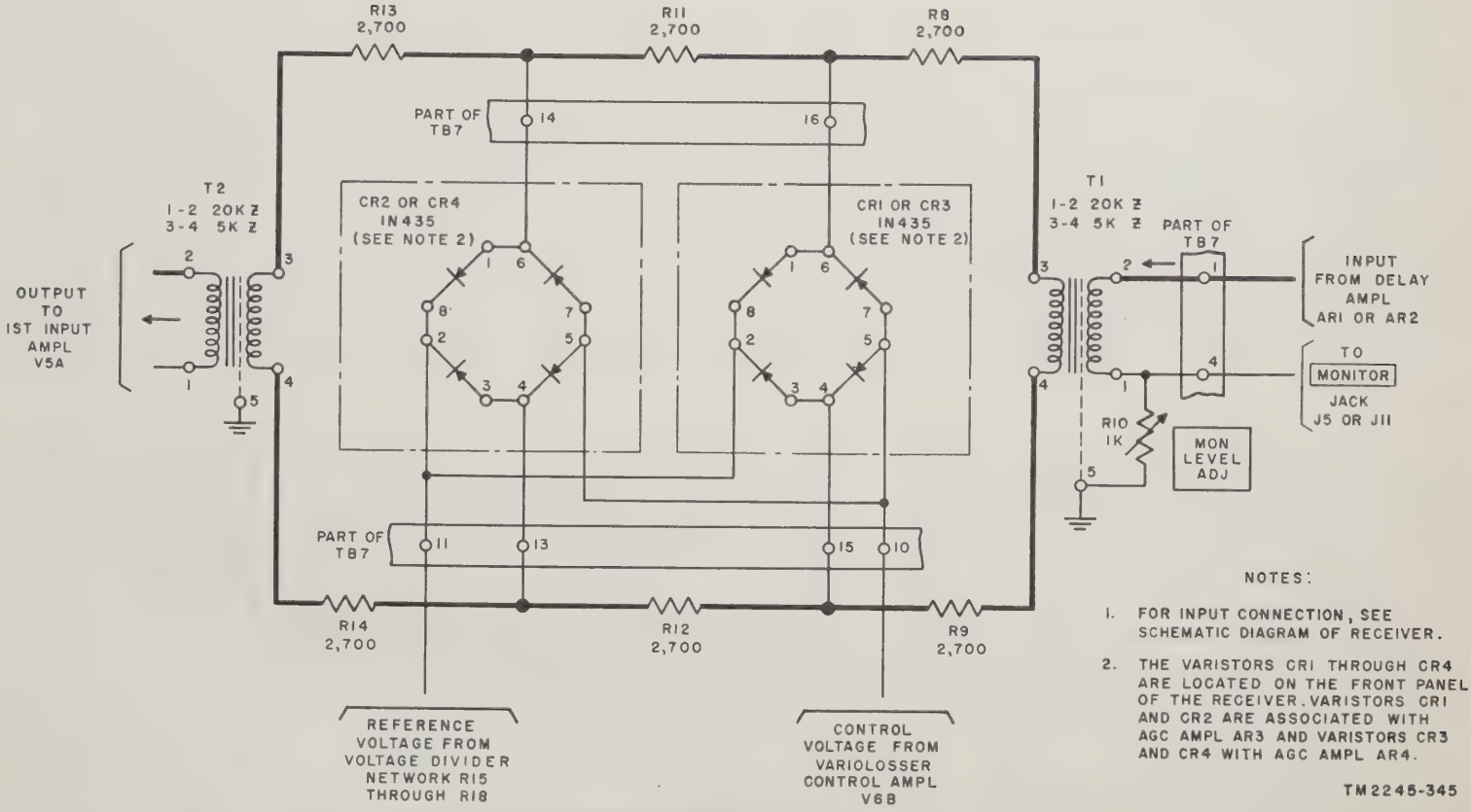



*Figure 118. Agc amplifier, variolosser circuit, simplified schematic diagram.*

to terminal 2. All varistor diodes now conduct and each varistor presents a low shunt resistance across the signal path, thereby increasing the attenuation of the variolosser. The signal loss in decibels through the variolosser is proportional to the voltage applied in the conducting direction across terminals 2 and 5 of each varistor. This voltage regulates the attenuation of the variolosser to compensate for changes in the input signal level caused by radio selective fading.

(2) Signals from secondary terminals 1 and 2 of transformer T2 are applied to the first input amplifier. Figure 119 is a simplified schematic diagram of the input amplifier circuit. The input amplifier circut is a three-stage amplifier consisting of tubes V5A, V5B, and V6A, which provides approximately 70-db voltage gain, stabilized by negative voltage feedback. Signals from the variolosser are applied across resistor R19 and pass through coupling capacitor C4 to grid resistor R21 and the grid of first input amplifier V5A. Cathode bias is supplied by resistor R25 bypassed to ground by capacitor C5A. Plate load resistor R26 is decoupled from the B-plus supply by resistor R27 bypassed to ground by capacitor C3A. The signals on the plate of amplifier V5A are applied to grid resistor R28 and the grid of second input amplifier V5B through coupling capacitor C6. Cathode bias is supplied by resistor R30 bypassed to ground by capacitor C5B. Signals at the junction of plate load resistor R31 and the plate of amplifier V5B are applied to grid resistor R33 and the grid of third input amplifier V6A through coupling capacitor C9. Resistor R32 in series with diode CR5 connected across the input circuit of the stage provides clamping action to prevent interstage blocking under conditions of momentary signal overload. Capacitors C10 and C16 attenuate frequencies above the signal band of the amplifier. Cathode bias is provided by tube current flow through resistor R34. Plate load for the stage is provided by resistors R43 and R44 in series. Negative voltage feedback from the plate of amplifier V6A is applied through capacitor C14 and resistor R35 to feedback resistor R20 which is in series with the input circuit of amplifier V5A. The output signals appearing at the junction of resistors R43 and R44 leave the input amplifier circuit and pass to second buffer amplifier V7B of the expanding circuit (*b* below).

(3) The signals at the plate of amplifier V6A are applied to the input of the gain control regulating circuits (fig. 120). These signals are fed through coupling capacitor C15 to the grid of first buffer amplifier V7A. Amplifier V7A is a cathode follower stage in which resistor R45 is the grid resistor; resistor R46, the cathode bias resistor, and resistor R47, the cathode load resistor. The signals from the cathode pass through coupling capacitor C18 and are impressed across primary terminals 1 and 2 of transformer T4. The center-tapped transformer secondary winding, terminals 3, 4, and 5, and diodes CR8 and CR9, form a full-wave variolosser control rectifier circuit operating into load resistor R42 which returns to ground at terminal 4 of transformer T4. The rectified positive control voltage at the common junction of diodes CR8 and CR9 is filtered by series resistor R41 and shunt capacitor C13 in series with resistor R40 to ground. The positive voltage from resistor R41 causes current to flow through diode CR7 in the conducting direction and through resistor R39 to ground, thereby maintaining the diode in the low resistance (closed) condition. From diode CR7, the control voltage is applied to a feedback shaping network consisting of resistors R36, R37, and R38, and capacitors C11 and C12. The shaping network determines the dynamic response time of the gain control circuit of the agc amplifier. The output of the shaping network from resistor R36 is applied to the grid of variolosser control amplifier V6B, a cathode follower stage. Cathode load for the stage is provided by resistor R29. The control voltage output from the cathode of amplifier V6B passes to control varistors CR1 (CR3)

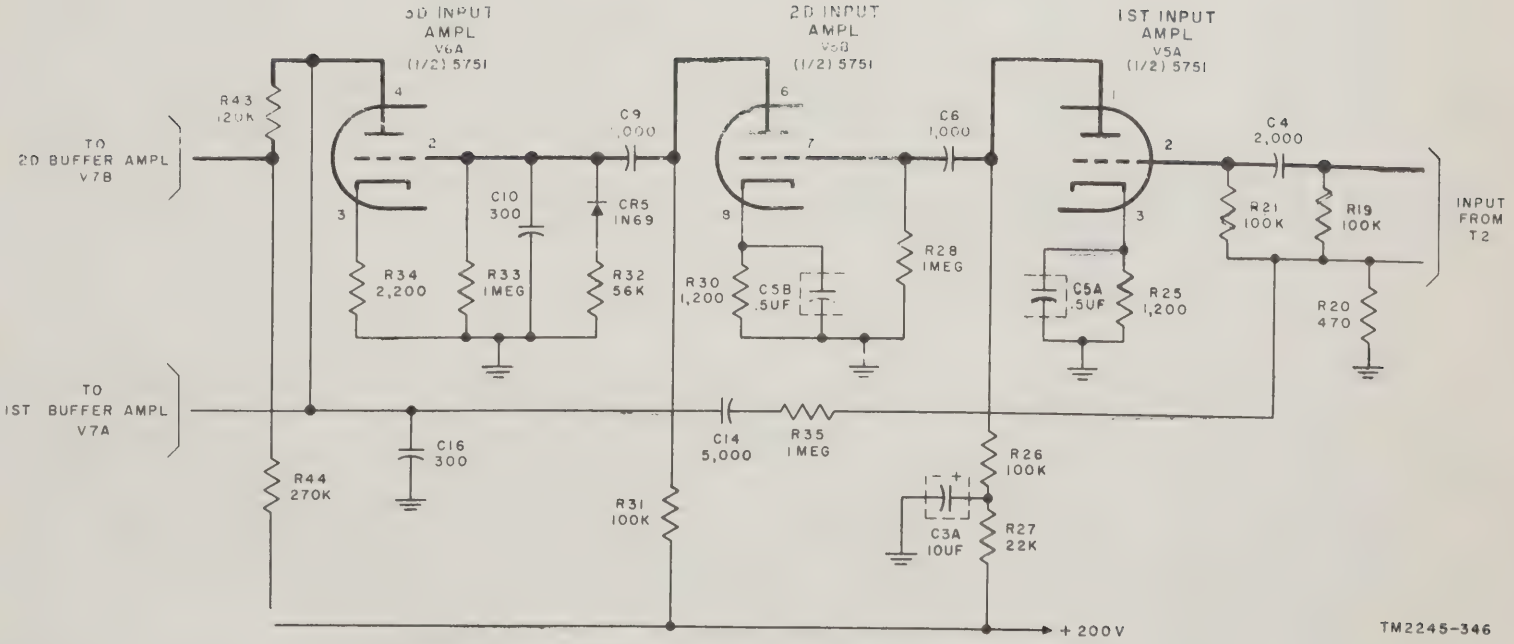



*Figure 119. Agc amplifier, input amplifier circuit, simplified schematic diagram.*

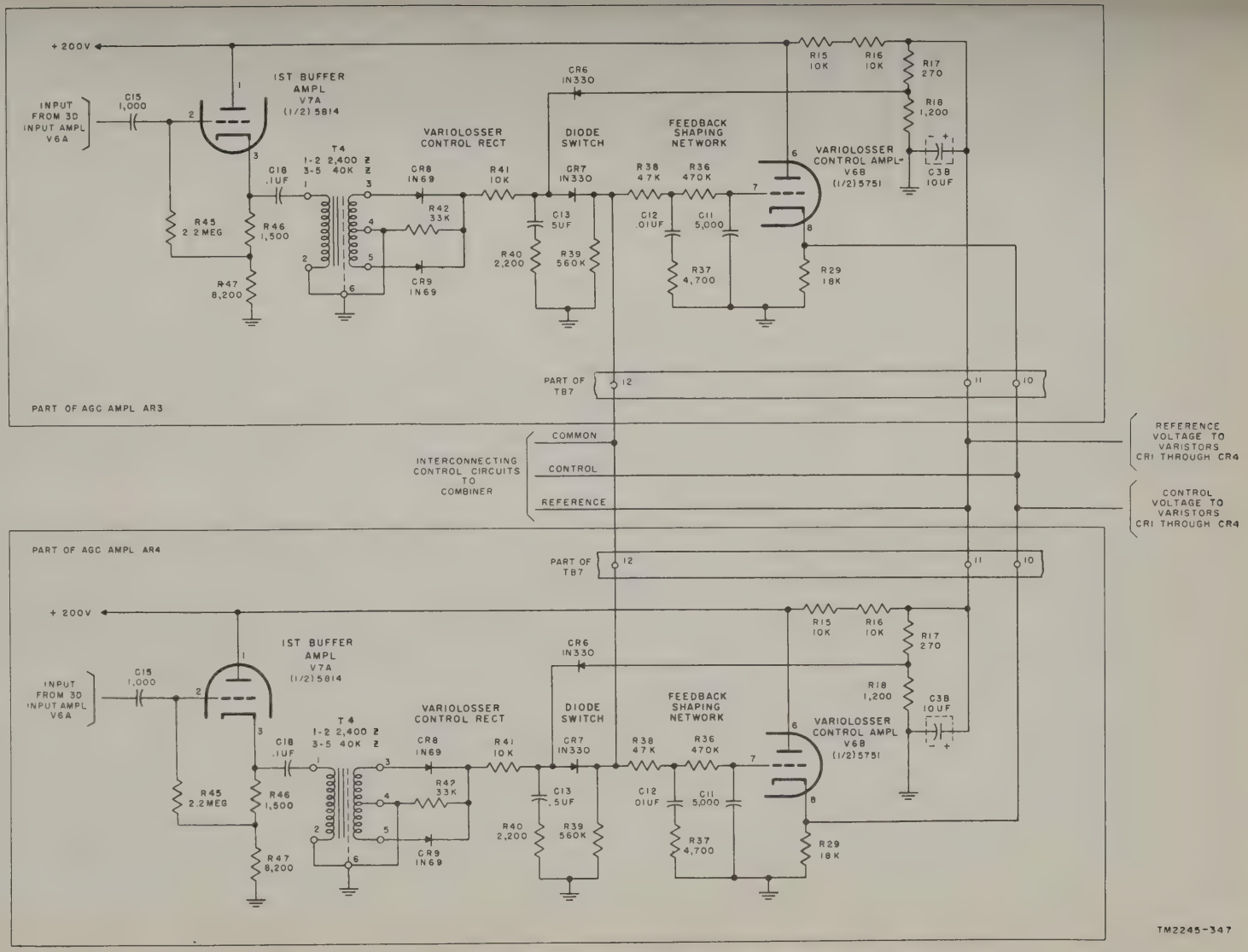



*Figure 120. Agc amplifier, gain control regulating circuits, simplified schematic diagram.*

and CR2 (CR4) by way of terminal 10 on terminal board TB7.

*b. Expanding Circuit.* Figure 121 is a simplified schematic diagram of the expanding circuit. The signals from third input amplifier V6A (*a*(2) above) enter the expanding circuit at the grid of second buffer amplifier V7B through coupling capacitor C17. Resistor R48 is the grid resistor and resistor R49 the cathode bias resistor. Cathode load is provided by resistor R50. Resistor R51 furnishes positive bias voltage for expander diodes CR10 and CR11 and also provides a monitor signal to METER SWITCH S1 through terminal 9 on terminal board TB7 (fig. 255). The cathode output signal from the junction of resistors R49 and R50 is applied through coupling capacitor C29 to the primary winding of transformer T5 at terminal 1 and returns to ground at terminal 2. The low-level signal from secondary terminals 6 and 8 is shunted by terminating resistor R52, and passes through expander diodes CR10 and CR11 to primary terminals 1 and 4, respectively, of transformer T6 with terminals 2 and 3 strapped to ground. The high-level control signal from secondary terminals 3 and 5 of transformer T5 are rectified by the full-wave rectifier composed of diodes CR12 and CR13. The negative side of the rectifier circuit at the junction of diodes CR12 and CR13 is biased positively with respect to ground by bias resistor R51. The positive side of the rectifier at center tap terminal 4 of transformer T5 connects through a damping network consisting of resistors R53 and R54 and capacitors C19 and C25 to center tap terminal 7 on transformer T5. The camping network filters the rectified control voltage and determines the dynamic response time of the expanding circuit. Control current entering terminal 7 of transformer T5 divides equally between the two halves of the winding. The current from terminal 6 flows through diode CR10 and one primary winding of transformer T6 from terminal 1 to ground at terminal 2. The current from terminal 8 on transformer T5 flows through diode CR11 and the other primary winding of transformer T6 from termina' 4 to ground at terminal 3. Since the control currents flow in opposite directions through the two primary windings of transformer T6 and are equal in magnitude, they induce no voltage in the secondary winding. When the signal level from second buffer amplifier V7B is at a maximum, the control current flowing through diodes CR10 and CR11 is also at a maximum causing them to assume the lowest impedance condition so that minimum loss is encountered by the signals passing from terminals 6 and 8 of transformer T5 to terminals 1 and 4 of transformer T6. When the output of second buffer amplifier V7B decreases, the control current flowing through diodes CR10 and CR11 decreases proportionately and causes the diodes to assume a higher impedance. This increases the loss encountered by the signals passing from transformer T5 to transformer T6. The increase in loss, expressed in decibels, is approximately equal to the signal decrease in decibels at the output of second buffer amplifier V7B. As result, the signal decrease at terminals 1 and 4 of transformer T6 is twice the signal decrease of terminals 6 and 8 of transformer T5 when both signals are expressed in decibels. The expanded signals from terminals 5 and 6 of transformer T6 are applied to the grid of first output amplifier V8A. Resistor R55 is the transformer terminating resistor and resistor R56, the cathode bias resistor. Plate load for the stage is provided by resistor R57. Signals at the plate of amplifier V8A are coupled to the grid of second output amplifier V8B through coupling capacitor C26. Resistor R58 is the grid resistor. Cathode bias is provided by resistor R60 and plate load by resistor R61. Gain stabilization is accomplished by negative voltage feedback from the plate of amplifier V8B to the cathode of amplifier V8A by way of capacitor C27 and resistor R59. The output signal from the plate of amplifier V8B leaves the agc amplifier through coupling capacitor C28 and terminal 2 on terminal board TB7.

*c. Diversity Operation.* The gain control regulating circuits of agc amplifiers AR3 and AR4 are permanently interconnected for two-channel diversity operation as shown in figure 120. For optimum combining, the level ratio of the two diversity signals leaving the gain control circuits must be identical to their ratio entering these circuits (par. 184*c*). This is accomplished by interconnecting the reference voltages of each agc amplifier and also interconnecting the variolosser control voltages so that control varistors CR1 and CR2 of agc Amplifier AR3 and control varistors CR3 and CR4 of agc Amplifier AR4 are all actuated by identical reference and control voltages This arrangement insures that the variolossers of the two agc amplifiers always have equal attenuation and, consequently, the ratio of the diversity signals at the output of the gain control circuits is maintained. The reference voltage interconnec-

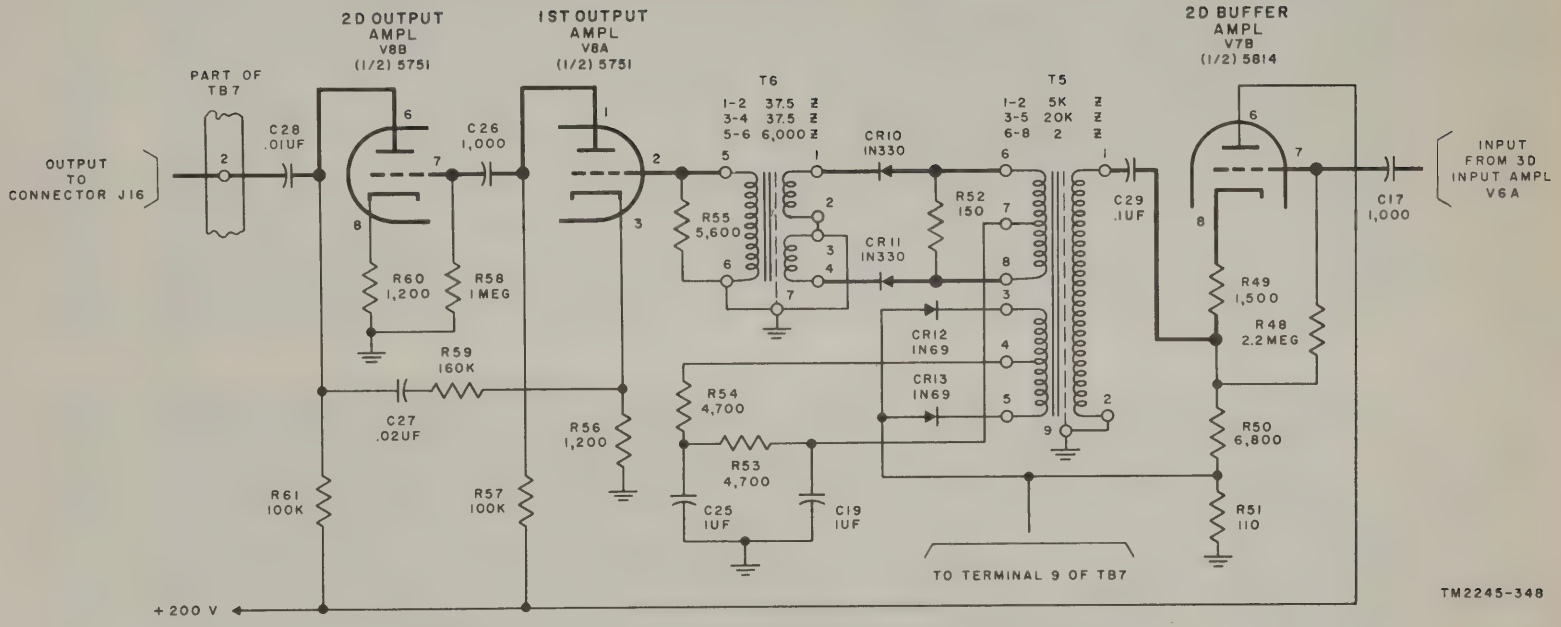



*Figure 121. Agc amplifier, expanding circuit, simplified schematic diagram.*

tion is established between terminal 11 on terminal board TB7 of agc amplifier AR4. The variolosser control voltage interconnection is established between terminal 10 or terminal board TB7 of agc amplifier AR3 and terminal 10 on terminal board TB7 of agc amplifier AR4. For optimum diversity combining the output level of the agc amplifier with the larger input signal must be maintained approximately constant over an input fading range of 40 db. This is accomplished by connecting the cathode of diode CR7 in agc amplifier AR3 to the cathode of diode CR7 in agc amplifier AR4. The connection is made between terminal 12 on terminal board TB7 of agc amplifier AR3 and terminal 12 on terminal board TB7 of agc amplifier AR4. The agc amplifier with the larger input signal produces a larger positive control voltage at the output of its variolosser control rectifier than is produced at the output of the variolosser control rectifier in the agc amplifier with the smaller input signal. The variolosser control rectifier with the larger output causes its associated diode CR7 to conduct and simultaneously biases diode CR7 of the other agc amplifier in the nonconducting direction. Nonconducting diode CR7 isolates its associated variolosser control rectifier from the feedback shaping network which follows. The conducting diode CR7 appears as a low resistance and passes the control voltage from its associated variolosser control rectifier to both feedback shaping networks. As a result, the variolossers of both agc amplifiers are under control of the agc amplifier with the stronger input signal, so that both gain control circuits of the agc amplifiers have equal amplification. Since the stronger signal is in control, the output of its gain control circuit, and consequently the output of its expanding circuit (par. 185*b*), is automatically maintained at a fixed level. Diode CR6 is a clamping diode for capacitor C13. The clamping voltage is obtained from the junction of resistors R17 and R18 and is slightly less positive than the reference voltage. The clamping action of diode CR6 allows only partial discharge of capacitor C13 during deep signal fades to shorten the recovery time of the gain control circuit. For optimum combining, the ratio of the two signals at the output of the gain control circuits is squared by the expanding circuit of the agc amplifier having the weaker input. The two signals are then applied to the combiner where they are serially added to operate a single telegraph receiving loop. For four-channel diversity operation the gain control regulating circuits of the agc amplifiers in one receiver are interconnected with the gain control regulating circuits of the agc amplifiers of a second receiver. The interconnections are established through the combiner into which both receivers operate. In this arrangement, all four gain control circuits of the agc amplifiers always have equal gain and this gain is determined by the agc amplifier having the stronger input signal. As a result, the output of the gain control circuits having the stronger input signal is maintained at a fixed level, and the relative output amplitudes of the four signals are the same as the relative input signal amplitudes. The amplitude ratios of the signals are then squared by the expanders of the three agc amplifiers having the weaker signals and are applied to the combiner where they are serially added to operate a single telegraph receiving loop.

*Figure 122. Receiver, AGC amplifier, schematic diagram.*

(Contained in separate envelope)

## 186. Receiver, Theory of Plate Supply

Plate supply PS1 of the receiver is identical with the plate supply used in the SUBGROUP MODULATOR. For the theory of the plate supply, refer to paragraph 166.

## 187. Receiver, Theory of Receiver Filters

(fig. 123)

Receiver filter FL1 and FL2 are identical hermetically sealed units, each containing a band-pass filter. The circuit configuration of the filter is shown in figure 123. The filter passes a band of frequencies extending from 50 cycles below to 50 cycles above the center frequency of its assigned carrier channel and rejects all other channel frequencies. The input impedance at terminals 1 and 2 is 600 ohms and the output impedance at terminals 3 and 4 is 100,000 ohms. For filter designations and frequencies refer to figure 255.

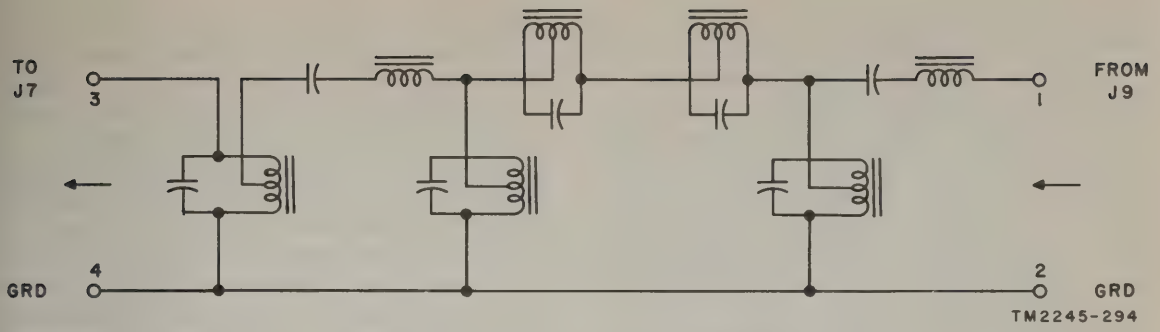



*Figure 123. Receiver filter, schematic diagram.*

## Section VIII. THEORY OF COMBINER

### 188. General

The combiner converts frequency-shift carrier signals into marking and spacing dc neutral telegraph signals. There are eight combiners in the AN/FGC–29 terminal, each containing an even- and an odd-numbered channel. The combiner designations and channel frequencies are listed in the table in paragraph 12*c*. The combiner accepts the diversity signals from the two associated even- and odd-numbered channel receivers. For two-channel diversity operation the diversity signals from the odd-numbered receiver are demodulated and added to operate the odd-numbered telegraph receiving loop. The two diversity signals from the even-numbered channel are similarly demodulated and added to operate the even-numbered telegraph receiving loop. When operated in four channel diversity, the combiner demodulates and adds all four diversity signals from the two receivers to operate the odd-numbered telegraph loop. The following discussion covers COMBINER CHANNELS 1 and 2 as a typical example. The other combiners operate in an identical manner except for the difference in their carrier signal frequencies.

### 189. Combiner, Block Diagram Analysis (fig. 124)

Figure 124 is a block diagram of the combiner showing channel 1 at the top of the figure and channel 2 at the bottom.

For a detailed discussion of the combiner circuits, refer to paragraph 190 and the schematic diagram (fig. 256).

*a. Channel 1 Signal Path.* The A and B path carrier signals from RECEIVER CHANNEL 1 are applied to A path amplifier V3 and B path amplifier V1, respectively, in adder AR1. The A and B path signals are raised to the proper power level in these amplifiers and are passed to discriminator Z1. The A path discriminator (discriminator network A) in discriminator Z1 converts the A path signal from a frequency-shift modulated carrier into an amplitude-modulated carrier, and the B path discriminator (discriminator net work B) similarly converts the B path signal. The amplitude-modulated carrier signals from discriminator networks A and B are applied to A and B path detectors V4 and V2, respectively, where they are demodulated and converted to dc telegraph signals. The A path signals pass through a low-pass filter, consisting of resistor R7, capacitor C4, and inductors L2 and L3, which shapes the telegraph signals for optimum performance. The B path signals pass through a similar low-pass filter consisting of resistor R15, capacitor C7, and inductors L1 and L4. The outputs of the low-pass filters are permanently connected in series-aiding so that the A path signal is arithmetically added to the B path signal. The combined dc signals pass to the DISCRIMINATOR and reverses switch S2; this permits the normal polarity of the signals to be reversed. IDLE-NORMAL switch S3 following switch S2, when in the IDLE position, holds receiving telegraph loop 1 in the idle (marking) condition for channel testing or alignment purposes. In the NORMAL position of switch S3, the signals pass to DIVERSITY switch S5. Switch S5 permits the combiner to be operated in either two-channel or four-channel diversity. In two-channel diversity operation, the channel 1 signals pass through switch S5 separately from the channel 2 signals and arrive at limiter amplifiers

V5A and V5B in adder AR1, which provide post detection limiting of the telegraph signals. Signals from the limiter amplifiers control the loop keyers consisting of parallel-connected pentodes V6 and V7 which furnish current to receiving telegraph loop 1 from —130 volts loop battery. LOOP CURRENT selector switch S1 permits operation of the receiving loop with either 20- or 60-ma loop current. LOOP CURRENT ADJUST resistor R36 is used for precise adjustment of the loop current.

*b. Channel 2 Signal Path.* The A and B path carrier signals from RECEIVER CHANNEL 2 are applied to A path amplifier V3 and B path amplifier V1, respectively, in adder AR2. The A and B path signals are raised to the proper power level in these amplifiers and are passed to discriminator Z2. The A path discriminator (discriminator network A) in discriminator Z2 converts the A path signal from a frequency-shift modulated carrier into an amplitude-modulated carrier, and the B path discriminator (discriminator network B) similarly converts the B path signal. The amplitude modulated carrier signals from discriminator networks A and B are applied to A and B path detectors V4 and V2, respectively, where they are demodulated and converted to dc telegraph signals. The A path signals pass through a low-pass filter consisting of resistor R7, capacitor C4, and inductors L6 and L7, which shapes the telegraph signals for optimum performance. The B path signals pass through a similar low-pass filter consisting of resistor R15, capacitor C7, and inductors L5 and L8. The outputs of the low-pass filters are permanently connected in series-aiding so that the A path signal is arithmetically added to the B path signal. The combined dc signals pass to the DISCRIMINATOR and reverses switch S2; this permits the normal polarity of the signals to be reversed. IDLE-NORMAL switch S4 following switch S2, when in the IDLE position, holds receiving telegraph loop 2 in the idle (marking) condition for channel testing or alignment purposes. In the NORMAL position of switch S4, the signals pass to DIVERSITY switch S5. Switch S5 permits the combiner to be operated in either two-channel or four-channel diversity. In two-channel diversity operation, the channel 2 signals pass through switch S5 separately from the channel 1 signals and arrive at limiter amplifiers V5A and V5B in adder AR2, which provide post detection limiting of the telegraph signals. Signals from the limiter amplifier control the loop keyers consisting of parallel-connected pentodes V6 and V7 which furnish current to receiving telegraph loop 2 from —130-volt loop battery. LOOP CURRENT SELECTOR switch S1 permits operation of the receiving loop with either 20- or 60-ma loop current. LOOP CURRENT ADJUST resistor R37 is used for precise adjustment of the loop current.

*c. Four-Channel Diversity.* DIVERSITY switch S5 makes it possible to operate the combiner in either two-channel (*a* and *b* above) or four-channel diversity. When operating in four-channel diversity, the A and B path signals from receiver 1 and receiver 2 are all modulated by the same telegraph signal. Switch S5, set for four-channel diversity operation, connects the signals from DISCRIMINATOR reversing switch S2 of adder AR1 and the signals from DISCRIMINATOR reversing switch S2 of adder AR2 in series-aiding so that the combined A and B signals of channel 1 are arithmetically added to the combined A and B signals of channel 2. The added signals are applied to limiter amplifiers V5A and V5B in adder AR1 and together control receiving telegraph loop 1. Receiving telegraph loop 2 is simultaneously held in the idle (marking) condition. Switch S5 also connects the gain control regulating circuits of the channel 1 receiver to the corresponding gain control regulating circuits of the channel 2 receiver. These connections permit the four agc amplifiers in the two receivers to regulate the levels of the four diversity signals for optimum combining. DIVERSITY switch S5 may be operating either manually at the terminal or electrically from a remote control station. Operation of the switch from a remote control station is made possible by the switch actuator part of switch S5. This actuator is a rotary solenoid powered by —130 volts dc at the combiner. Control circuits for the solenoid are extended to the remote control station.

*d. Power Circuits.* The B-plus voltage for A path amplifier V3 and B path amplifier V1 in adder AR1 is furnished from RECEIVER CHANNEL 1. The B-plus voltage for A path amplifier V3 and B path amplifier V1 in adder AR2 is furnished from RECEIVER CHANNEL 2. The negative cathode voltage for the limiter amplifiers V5A and V5B in adders AR1 and AR2 is furnished by the negative bias rectifier CR1 and CR2 in each adder. The negative bias rectifiers accept 230 volts ac at 50 or 60 cps and deliver

−200 volts dc. Loop battery voltages of −130 volts dc from the LOOP BATTERY PANEL are applied to loop keyers V6 and V7 in adders AR1 and AR2 and furnish current for the operation of the receiving telegraph loops. The −130-volt battery applied to adder AR2 also operates the DIVERSITY switch actuator part of switch S5. Transformers T1 and T2 in transformer reactor assembly Z3 accept 230 volts ac at 50 or 60 cps, and furnish heater voltage of 6.3 volts ac to the tubes in adders AR1 and AR2, respectively.

*Figure 124. Combiner, block diagram.*
(Contained in separate envelope)

## 190. Combiner, Schematic Diagram Analysis (fig. 256)

The signal paths of the combiner are shown in detail on the schematic diagram (fig. 256), with the switches arranged for two-channel diversity operation and 60-ma loop current. In the following discussion, circuits that are identical in both channels are discussed with reference to channel 1. When reference symbols for channel 2 differ from channel 1 they are given in parentheses following the channel 1 symbol.

*a. A and B Path Circuits* (fig. 125).

(1) *A path.* The A Path signals from the channel 1 (channel 2) receiver enter the combiner at terminal R (T) on connector J10 (fig. 256) and pass directly to terminal 13 on terminal board TB4 of adder AR1 (AR2) and then to LEVEL ADJUST A resistor R11 (fig. 125). The circuit details of adder AR1 (AR2) are both shown on the schematic diagram of the combiner (fig. 256) and on the schematic diagram for the adder (fig. 128). From the variable arm of resistor R11 the signals are applied to the control grid of A path amplifier V3. Resistor R4 is the screen grid dropping resistor which is bypassed to ground by capacitor C1B. Cathode bias for the stage is furnished by resistor R6. Discriminator Z1 (Z2) is a sealed unit containing separate A path and B path discriminator networks. The signals at the plate of A path amplifier V3 enter discriminator network A at terminal 1 on discriminator Z1 (Z2) through terminal 1 on terminal board TB4 of adder AR1 (AR2). The primaries of transformers TRA1 and TRA2 in series form the plate load for amplifier V3. The secondary of transformer TRA1 is tuned somewhat below the channel spacing frequency by tuning capacitor CA1 and A TRIMMER capacitors on terminals 1 through 4. Therefore this winding develops a larger signal voltage for the spacing frequency than for the marking frequency. The secondary of transformer TRA2 is tuned somewhat above the channel marking frequency by tuning capacitor CA2 and A TRIMMER capacitors on terminals 5 through 8. Therefore this winding develops a larger signal voltage for the marking frequency than for the spacing frequency. The signals from the tuned circuits appearing on terminals 2, 3, and 4 of discriminator Z1 (Z2) pass to terminals 2, 3, and 4, respectively, on terminal board TB4 of adder AR1 (AR2). Signals from the spacing resonant circuit appearing on terminals 4 and 3 of terminal board TB4 are demodulated by A path detector V4A. The resulting dc signals appear across capacitor C3. Signals from the marking resonant circuit appearing on terminals 2 and 3 of terminal board TB4 are demodulated by A path detector V4B. The resulting dc signals appear across capacitor C2. Since the dc signal voltage at the cathodes of detectors V4A and V4B are both positive with respect to the common sides of capacitors C2 and C3, the dc output voltage, taken between the cathodes, is the arithmetical difference of the voltages across capacitors C2 and C3. When a spacing frequency is received, the rectified voltage across capacitor C3 is larger than that across capacitor C2, so that the cathode of tube V4A is positive with respect to the cathode of tube V4B. When a marking frequency is received, the signal voltage across capacitor C2 is larger than that across capacitor C3, so that the cathode of detector V4A is negative with respect to the cathode of detector V4B. Resistors R19 and R10 constitute the load for detector V4A, and resistors R8 and R9 form the load for detector V4B. BIAS ADJUST A resistor R19 in conjunction with fixed resistor R8 permits

the signal voltage from detector V4A to be made larger or smaller than the signal voltage from detector V4B to compensate for bias in the received signal. The dc signals at terminals 7 and 5 on terminal board TB4 of adder AR1 (AR2) pass through terminals 1 (17) and 3 (15) on terminal board TB6 (TB7) of transformer-reactor assembly Z3 to reactors L2 (L7) and L3 (L6), respectively. After passing through the reactors, the dc signals return to adder AR1 (AR2) at terminals 8 and 6 of terminal board TB4 from terminals 2 (18) and 4 (16) of terminal board TB6 (TB7) of transformer reactor assembly Z3. Reactors L2 (L7) and L3 (L6) and capacitor C4 comprise a low-pass filter with a cutoff frequency at approximately 40 cps which suppresses carrier ripple and removes interfering frequencies lying above the signaling range. The A path signals pass through the filter network and appear across filter load resistor R7.

(2) *B path.* The B path signals from the channel 1 (channel 2) receiver enter the combiner at terminal S (U) on connector J10 (fig. 256) and pass directly to terminal 14 on terminal board TB4 of adder AR1 (AR2) and then to LEVEL ADJUST B resistor R5 (fig. 125). From the variable arm of resistor R5, the signals are applied to the control grid of B path amplifier V1. Resistor R12 is the screen grid dropping resistor and is bypassed to ground by capacitor C1A. Cathode bias for the stage is furnished by resistor R14. Discriminator Z1 (Z2) is a sealed unit containing separate A path and B path discriminator networks. The signals at the plate of B path amplifier V1 enter discriminator network B at terminal 5 on discriminator Z1 (Z2) through terminal 25 on terminal board TB4 of adder AR1 (AR2). The primaries of transformers TRB1 and TRB2 in series form the plate load for stage V1. The secondary of transformer TRB1 is tuned somewhat below the channel spacing frequency by tuning capacitor CB1 and B TRIMMER capacitors on terminals 1 through 4. Therefore this winding develops a larger signal voltage for the spacing frequency than for the marking frequency. The secondary of transformer TRB2 is tuned somewhat above the channel marking frequency by tuning capacitor CB2 and B TRIMMER capacitors on terminals 5 through 8. Therefore this winding develops a larger signal voltage for the marking frequency than for the spacing frequency. The signals from the tuned circuits appearing on terminals 6, 7, and 8 of discriminator Z1 (Z2) pass to terminals 26, 27, and 28. respectively, on terminal board TB4 of adder AR1 (AR2). Signals from the spacing resonant circuit appearing on terminals 28 and 27 of terminal board TB4 are demodulated by B path detector V2A. The resulting signals appear across capacitor C6. Signals from the marking resonant circuit appearing on terminals 26 and 27 of terminal board TB4 are demodulated by B path detector V2B. The resulting dc signals appear across capacitor C5. Since the dc signal voltage at the cathodes of detectors V2A and V2B are both positive with respect to the common sides of capacitors C5 and C6, the dc output voltage, taken between the cathodes, is the arithmetical difference of the voltage across the capacitors. When a spacing frequency is received, the rectified voltage across capacitor C6 is larger than that across capacitor C5, so that the cathode of tube V2A is positive with respect to the cathode of tube V2B. Whan a marking frequency is received, the signal voltage across capacitor C5 is larger than that across capacitor C6, so that the cathode of detector V2A is negative with respect to the cathode of detector V2B. Resistors R13 and R18 constitute the load for detector V2A and resistors R16 and R17 form the load for detector V2B. BIAS ADJUST B resistor R13, in conjunction with fixed resistor R16, permits the signal voltage from detector V2A to be made larger or smaller than the signal voltage from detector V2B to compensate for bias in the received signal. The dc signals at terminals 23 and 21 on terminal board TB4 of adder AR1 (AR2) pass through terminals 5 (13) and 7 (11) on terminal

board TB6 (TB7) of transformer-reactor assembly Z3 to reactors L4 (L5) and L1 (L8), respectively. After passing through the reactors, the dc signals return to adder AR1 (AR2) at terminals 24 and 22 of terminal board TB4 from terminals 6 (14) and 8 (12) of terminal board TB6 (TB7) of transformer-reactor assembly Z3. The reactors L4 (L5) and L1 (L8) and capacitor C7 comprise a low-pass filter with a cutoff frequency at approximately 40 cps which suppresses carrier ripple and removes interfering frequencies lying above the signaling range. The B path signals pass through the filter network and appear across filter load resistor R15.

(3) *Combining A and B path signals.* The A path signals appearing across resistor R7 and the B path signals appearing across resistor R15 are added in series and the resultant channel 1 (channel 2) signal passes through DISCRIMINATOR switch S2 to terminals 5 and 8 on terminal board TB1 of adder AR1 (AR2). Switch S2 is provided to allow the polarity of the dc telegraph signals to be reversed. DISCRIMINATOR OUTPUT pin jacks J1 and J2 permit measurement of the A and B path signals at the output of switch S2.

*Figure 125. Combiner, A and B signal paths, partial schematic diagram.*

(Contained in separate envelope)

*Figure 126. Combiner, adder, schematic diagram.*

(Contained in separate envelope)

*b. Diversity Switching Circuits, Two-Channel Diversity.* Figure 127 is a simplified schematic diagram of the diversity switching circuits with DIVERSITY switch S5 set in the 2 CHANNEL LOOPS 1 & 2 position and IDLE-NORMAL switches S3 and S4 both set in the NORMAL position. When switch S5 is set for two-channel diversity, channel 1 and channel 2 operate independently. The side of the channel 1 signal path from terminal 5 to terminal 11 on terminal board TB1 of adder AR1 passes through switch S3. The other side of this signal path from terminal 8 to terminal 12 on terminal board TB1 passes through contacts 2 or 5, and 3 of switch S5, section 2B. This circuit arrangement passes the signals in adder AR1 from DISCRIMINATOR switch S2 to first limiter amplifier V5A. When switch S3 is placed in the IDLE position, the channel 1 signals are interrupted and −200 volts dc is applied from terminal 9 on terminal board TB4 to terminal 11 on terminal board TB1, both in adder AR1. This potential holds first limiter amplifier V5A of adder AR1 in the nonconducting condition to transmit a continuous marking signal to receiving loop 1. Simultaneously, switch S3 applies 6.3 volts ac from terminals 1 and 2 on terminal board TB1 of adder AR1 to CHANNEL 1 LOOP IDLE INDICATOR lamp I 2, causing it to glow. The side of the channel 2 signal path from terminal 5 to terminal 11 on terminal board TB1 of adder AR2 passes through contacts 8 or 11, and 9 of switch S5, section 2B, and switch S4. The other side of this signal path from terminal 8 to terminal 12 on terminal board TB1 of adder AR2 passes through contacts 2 or 5, and 4 of switch S5, section 2A. This circuit arrangement passes the signals in adder AR2 from DISCRIMINATOR switch S2 to first limiter amplifier V5A. When switch S4 is placed in the IDLE position, the channel 2 signals are interrupted and −200 volts dc is applied from terminal 9 on terminal board TB4 to terminal 11 on terminal board TB1 of adder AR2. This potential holds first limiter amplifier V5A of adder AR2 in the nonconducting condition to transmit a marking signal to receiving loop 2. Simultaneously, switch S4 applies 6.3 volts ac from terminals 1 and 2 on terminal board TB1 of adder AR2 to CHANNEL 2 LOOP IDLE INDICATOR lamp I 3, causing it to glow.

*c. Loop Keying Circuits.* Figure 128 is a simplified schematic diagram of the dc loop keying circuits in adder AR1 (AR2) arranged for 60-ma loop current. The dc signals at terminals 11 and 12 on terminal board TB1 are applied between the grid of first limiter amplifier V5A through grid limiting resistor R20, and the cathode circuit at the junction of resistors R25 and R26. First limiter amplifier V5A and second limiter amplifier V5B constitute a direct-coupled two-stage dc amplifier. Proper cathode potentials for stages V5A and V5B are provided by a voltage divider network consisting of resistors R25 through R28 and bypass capacitor C10. This network is connected between ground and a source of −200 volts dc supplied by a half-wave rectifier consisting of diodes CR1 and CR2, capacitor C13, and resistors R29, R30, and R38. A grounded source

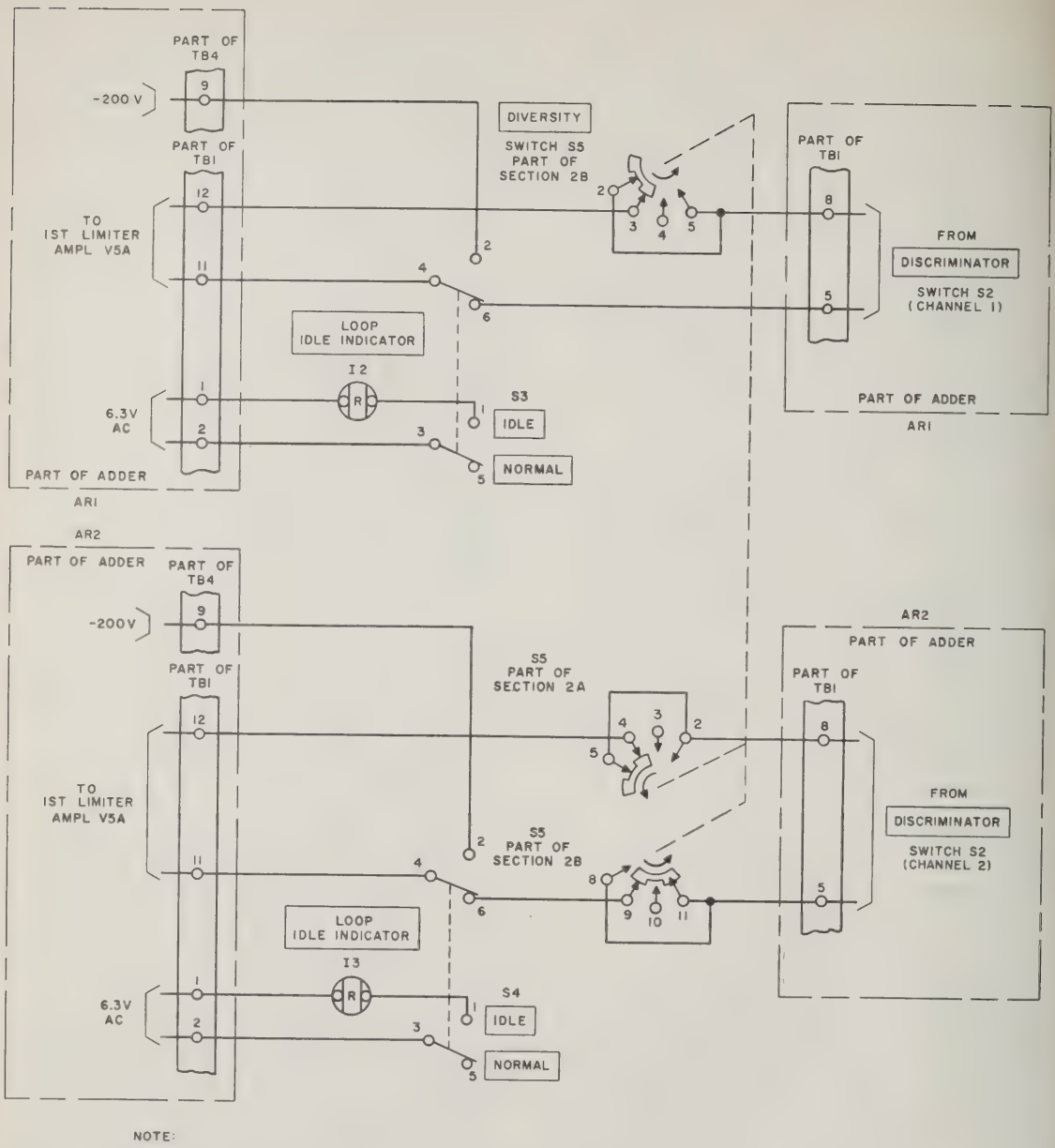



*Figure 127. Combiner, diversity switching circuits, two-channel diversity, simplified schematic diagram.*

of 230 volts ac is applied to the rectifier from terminal 6 on terminal board TB1. The rectifier delivers —200 volts dc across capacitor C13. Resistors R23 and R24 are load resistors for the rectifier to improve its voltage regulation. The voltage across resistors R25 and R26 in series biases first limiter amplifier V5A, so that it will cut off when —200 volts is applied to its grid (from terminal 9 of terminal board TB4 to terminal 11 of terminal board TB1) by IDLE-NORMAL switch S3 (S4) as discussed in *b* above. Capacitor C10 prevents self-oscillation of the limiter stages. The voltage drop across resistor R26 provides the proper operating bias for the stage. Resistors R27 and R28 bias the cathode of second limiter amplifier V5B and the grids of loop keyer stages V6 and V7 to the proper operating potential. Plate load is furnished by resistor R21 and R22, respectively, for stages V5A and V5B. Spacing signals applied to grid limiting resistor R20 of first limiter amplifier V5A are greatly positive with respect to the cathode of this stage, while marking signals are equally negative. When a spacing signal is received, the grid follows the positive polarity of the signal to the point where the grid conducts. The grid input impedance then drops to a low value compared with that of resistor R20 and the positive swing on the grid is substantially halted at a potential slightly positive with respect to the cathode potential. Under this condition, tube V5A is carrying maximum plate current, and the voltage drop across resistor R21 brings the plate to its maximum negative potential. This potential is directly applied to the grid of tube V5B, causing it to cut off so that no plate current flows. The potential now existing at the junction of resistors R27 and R28 and which is applied to the control grids of loop keyer tubes V6 and V7 is well below the —130-volt potential applied to the cathodes of these tubes from terminal 17 of terminal board TB4. The tubes are thereby maintained in the nonconducting condition corresponding to a spacing loop signal. When a marking signal is received, the negative polarity of the signal biases the grid of tube V5A well beyond cutoff so that the voltage at its plate, and consequently at the grid of V5B, tries to rise to ground potential. The rise is limited by grid conduction in tube V5B to a value slightly positive with respect to its cathode potential, and plate-to-cathode flow in tube V5B becomes maximum. This current, flowing through resistor R27, causes the cathode of tube V5B and the grids of tubes V6 and V7 to rise in potential until halted by grid conduction of the loop keyers at a value slightly above the —130-volt cathode potential. Loop keyers V6 and V7 thereby conduct causing a marking current to flow from the receiving loop circuit on terminal 9 of terminal board TB1 to —130 volts. Resistors R31 and R32 serve to suppress parasitic oscillations. The magnitude of the marking loop current is determined by the potential applied to the screen grids of loop keyers V6 and V7. The potential applied to the screen grids is controlled by LOOP CURRENT selector switch S1, resistors R1, R2, and R3, and front panel LOOP CURRENT ADJUST resistor R36 (R37) which together make up a voltage divider network between ground and —130 volts dc. In the 60MA position of switch S1, current flows into the voltage divider from ground through contacts 11 and 12 of switch S1 to resistor R36 (R37) through terminal 3 of terminal board TB1. From resistor R36 (R37) the current flows through terminal 4 on terminal board TB1 of adder AR1 (AR2), contacts 9 and 8 of switch S1, and resistors R1 and R2 in series. The current then passes through contacts 6 and 5 of switch S1 and resistor R3 to —130 volts dc at terminal 17 of terminal board TB4. In the 60MA position therefore, LOOP CURRENT ADJUST resistor R36 (R37) is located at the positive (ground) end of the voltage divider network so that the potential applied from its adjustable arm to the screen grids of tubes V6 and V7 through terminal 10 of terminal board TB1 is greatly positive with respect to the potential of their cathodes. The highly positive screen potential reduces the plate-to-cathode resistance of the tubes to a low value and permits a 60-ma plate current to flow from the telegraph loop circuit at terminal 9 of terminal board TB1 to —130 volts dc. Resistor R33 is provided to limit the maximum screen current of tubes V6 and V7 to a safe value. Damping capacitor C11 suppresses high-frequency transients which may occur when operating with an inductive load in the external loop circuit. When LOOP CURRENT selector switch S1 is set in the 20MA position, current enters the voltage divider from ground through switch contacts 11 and 10 and resistors R2 and R1 in series. From resistor R1 the current passes through switch contacts 8 and 7 and resistor R36 (R37), and then through switch contacts 4 and 5 and resistor R3 to —130 volts dc at terminal 17 on terminal board

TB4. This arrangement places resistor R36 (R37) near the negative end of the voltage divider so that the screen potential applied to tubes V6 and V7 is reduced. The lowered screen potential increases the plate-to-cathode resistance of the tubes and limits the loop current to 20 ma. LOOP CURRENT ADJUST resistor R36 (R37) permits a range of screen potential adjustment to compensate for the particular resistance of the associated external loop circuit. The receiving telegraph loop 1 (loop 2) circuit from terminal 9 on terminal board TB1 of adder AR1 (AR2) passes in turn through EQUIP jack J3 (J6), LOOP jack J4 (J7), and MONITOR jack J5 (J8) and leaves the combiner at terminal A (B) on connector J10 (fig. 256).

*d. Diversity Switching Circuits, Four-Channel Diversity.* When operating in four-channel diversity, the channel 1 and channel 2 signals are added in the combiner and together operate receiving loop 1. Receiving loop 2 becomes idle and stands in the marking condition. Figure 129 is a simplified schematic diagram of the diversity switching circuits with DIVERSITY switch S5 set in the 4-CHANNEL LOOP 1 ONLY position, and IDLE-NORMAL switches S3 and S4 both set in the NORMAL position. The side of the channel 1 signal path leaving adder AR1 at terminal 5 on terminal board TB1 passes through switch S3 and re-enters adder AR1 at terminal 11 on terminal board TB1. The other side of the channel 1 signal path leaving adder AR1 at terminal 8 on terminal board TB1 passes through contacts 5 or 2, and 4 and then through contacts 10, and 8 or 11 of switch S5, section 2B, and connects to the side of the channel 2 signal path leaving adder AR2 at terminal 5 on terminal board TB1. The other side of the channel 2 signal path leaving adder AR2 at terminal 8 on terminal board TB1 passes through contacts 2 or 5, and 3 of switch S5, section 2A, and enters adder AR1 at terminal 12 on terminal board TB1. This arrangement interconnects the signal path of channel 1 with the signal path of channel 2 so that the signals from the two paths are combined in series aiding. The composite signal is applied to the input of first limiter amplifier V5A in adder AR1. Contacts 8 or 11, and 9 of switch S5, section 2A, connect −200 volts from terminal 9 on terminal board TB4 to terminal 11 on terminal board TB1 of adder AR2 to hold the loop keying circuits of channel 2 in the marking condition. Contacts 8 or 11, and 10 of switch S5, section 3B, applies 6.3 volts ac from terminals 1 and 2 of terminal board TB1 of adder AR2 to CHANNEL 2 LOOP IDLE INDICATOR lamp I 3, causing it to glow. Contacts 8 or 11, and 9 of switch S5, section 2A, and contacts 8 or 11, and 10 of section 3B, duplicate the function of IDLE-NORMAL switch S4 set in the IDLE position. Switch S4 is inoperative when the combiner is operating in four-channel diversity. IDLE-NORMAL switch S3 operates as explained in *b* above. The gain control regulating circuits of the channel 1 receiver and channel 2 receiver are interconnected for four-channel diversity (par 185*c*). The interconnections are made in the combiner by switch S5 in the 4-CHANNEL LOOP 1 ONLY position. The common voltage circuit of the channel 1 receiver enters the combiner at terminal E on connector J10 and passes through contacts 4 and 2, or 5 of switch S5, section 3B, to the common voltage circuit of the channel 2 receiver which enters the combiner at terminal K on connector J10. The control voltage circuit of the channel 1 receiver enters the combiner at terminal F on connector J10 and passes through contacts 2 or 5, and 3 of switch S5, section 3A, to the control voltage circuit of the channel 2 receiver which enters the combiner at terminal L on connector J10. The reference voltage circuit of the channel 1 receiver enters the combiner at terminal G on connector J10 and passes through contacts 8 or 11, and 9 of switch S5, section 3A, to the reference voltage circuit of the channel 2 receiver which enters the combiner at terminal M on connector J10.

*e. Remote Control Circuits.* DIVERSITY switch S5 can be operated manually at the combiner or electrically from a remote control station. Figure 130 shows the switch actuator part of DIVERSITY switch S5 in COMBINER CHANNELS 1 and 2 with the control circuit extended to a typical remote control station. For details of the remote switching circuits for all combiners in the receiving terminal, refer to paragraph 209. The rotary solenoid actuator is mounted at one end of switch S5 and is coupled to the rotary shaft of the switch through a ratchet mechanism. Each time the solenoid operates, the switch is stepped one position counterclockwise (viewed from the panel end of the switch). Alternate positions of the switch arrange the combiner for two-channel or four-channel diversity operation. The particular position of the switch is indicated by the manual operating knob and front panel marking.

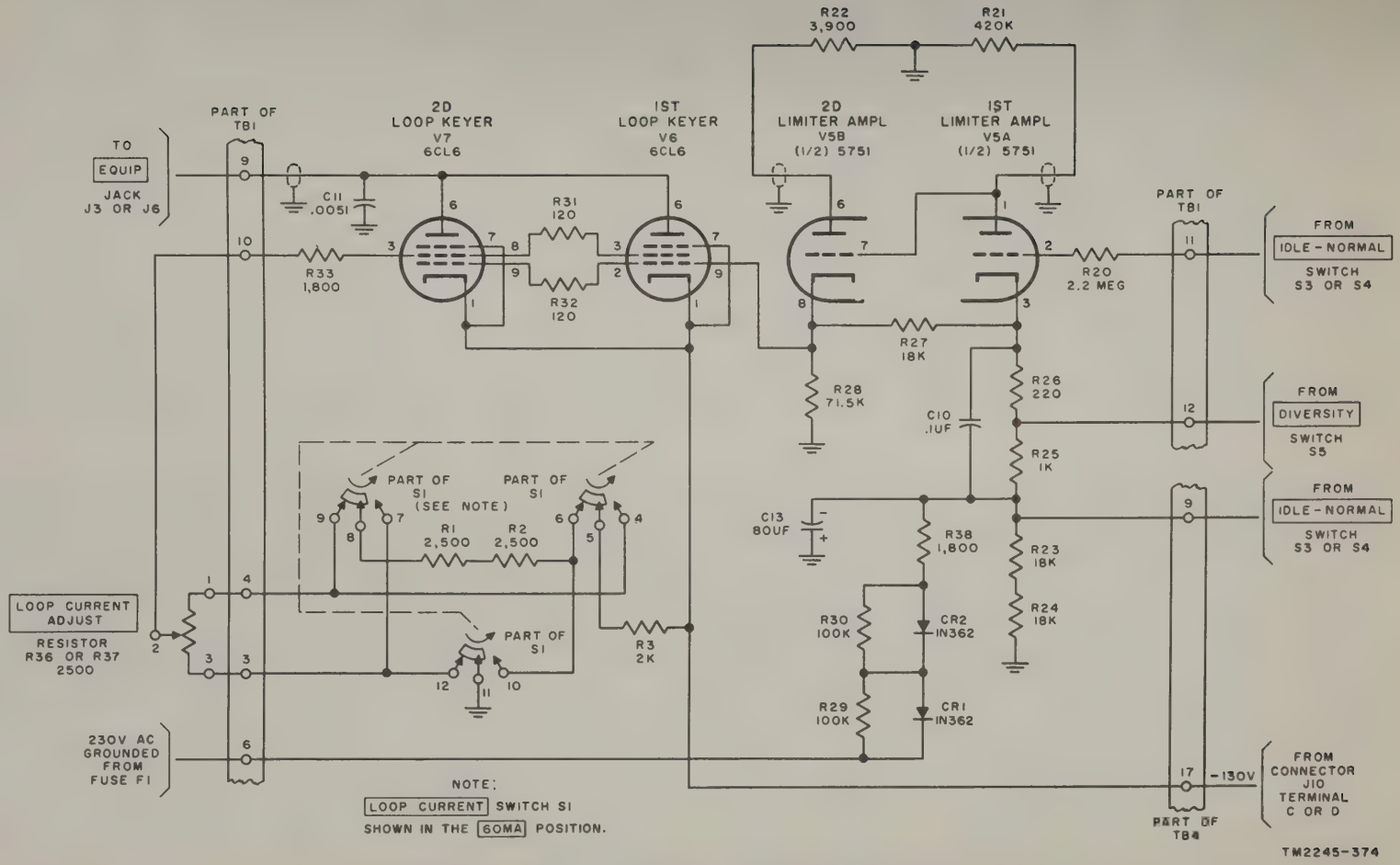



*Figure 128. Adder, loop keying circuits, simplified schematic diagram.*

When DIVERSITY switch S5 is in the 2-CHANNEL LOOPS 1 and 2 position, a control circuit is established from −130 volts on terminal 17 of terminal board TB4 of adder AR2 through the solenoid winding, and contacts 9 and 3 of switch S5, section 1, to terminal N of connector J10 of the combiner. From here the circuit continues through the mating terminal of plug P112, cable W112, to terminal 13 of terminal board TB112 which connects to terminal 1 of terminal board TB104 in cabinet 4. At this point, the circuit leaves the AN/FGC–29 terminal and is extended to the four-channel diversity (nonlocking type) switch at the remote location. When this switch is closed to ground, current flows in the control circuit, energizing the solenoid which steps the switch to the next position (4-CHANNEL LOOP 1 ONLY). This action opens the connection between terminals 3 and 9 of switch S5, section 1, and closes terminals 4 and 9, thereby transferring the solenoid connection from the four-channel diversity switch at the remote control station to the two-channel diversity switch (nonlocking type). Connection to the two-channel diversity switch is established from terminal 4 of switch S5, section 1, through terminal P of connector J10 and plug P112, cable W112, terminal 14 of terminal board TB112, and terminal 2 of terminal board TB104. When this switch is closed to ground, the solenoid is again energized and advances the DIVERSITY switch one position (2-CHANNEL LOOPS 1 and 2 position) and transfers control back to the four-channel diversity switch in the remote control station. When switch S5 is in the 4-CHANNEL LOOP 1 ONLY position, the −130-volt battery potential appears across the two-channel diversity switch which is always open except when being operated. As a result, the four-channel diversity indicator neon lamp glows indicating that the combiner is arranged for four-channel diversity operation. Spark suppression for the solenoid control circuits is furnished by diode CR3 in series with resistor R39 connected across the solenoid winding, and capacitors C14 and C15 bridged across terminals 3 and 9 and terminals 4 and 9, respectively, of switch section 1.

*f. Jacks and Controls.* Two groups of jacks are used to provide connections to the telegraph loop circuits of the combiner for measuring, patching, and monitoring the output signals of channel 1 and channel 2. In each group, there is an EQUIP jack, a LOOP jack, and a MONITOR jack, used with cords equipped with single plugs. The EQUIP jack permits the output of the channel to be patched to the corresponding LOOP jack of another channel. The LOOP jack permits the receiving telegraph loop to be patched to the corresponding EQUIP jack of another channel. The MONITOR jack is in series with the receiving loop on the output side of the LOOP jack and permits measurement of the marking current or signal bias in the receiving loop.

## 191. Combiner, Theory of Transformer-Reactor Assembly Z3

Transformer-reactor assembly Z3 consists of inductors L1 through L8 and power transformers T1 and T2, which are used to supply tube heater voltages for the combiner. A detailed schematic diagram of the transformer-reactor assembly Z3 is shown in figure 131. Transformer T1 supplies heater power for the tubes in channel 1, and transformer T2 supplies heater power for the tubes in channel 2. Channel 1 and channel 2 are electrically identical; where components bear different reference symbols for channel 1 and channel 2, parentheses are used in the text to indicate channel 2. Transformers T1 and T2 are energized by 230 volts ac (50 or 60 cps) applied between terminals 1 and 4 on each transformer from terminals 7 and 8 on terminal board TB7. The secondary winding between terminals 8 and 10 on transformer T1 (T2) supplies 6.3 volts ac to terminals 17 (1) and 18 (2) on terminal board TB6 (TB7). The center tap of the winding, on terminal 9 of transformer T1 (T2), is grounded through terminal 13 (5) on terminal board TB6 (TB7). The 6.3 volts ac from terminals 17 (1) and 18 (2) on terminal board TB6 (TB7) is applied to the heaters of tubes V1 through V4 in adder AR1 (AR2) through terminals 10 and 12 of terminal board TB4. This heater voltage is also applied to terminals 1 and 2 on terminal board TB1 of adder AR1 (AR2) for the operation of LOOP IDLE INDICATOR lamp I 2 (I 3). The secondary winding between terminals 5 and 7 on transformer T1 (T2) supplies 6.3 volts to terminals 15 (3) and 16 (4) on terminal board TB6 (TB7) which is applied to the heaters of tubes V5, V6, and V7 in adder AR1 (AR2) through terminals 18 and 20 on terminal board TB4. The center tap of the winding, on terminal 6 of transformer T1 (T2), returns to −130 volts dc at terminal C (D) of connector J10 through terminal 14 (6) on terminal block TB6 (TB7). This is done to main-

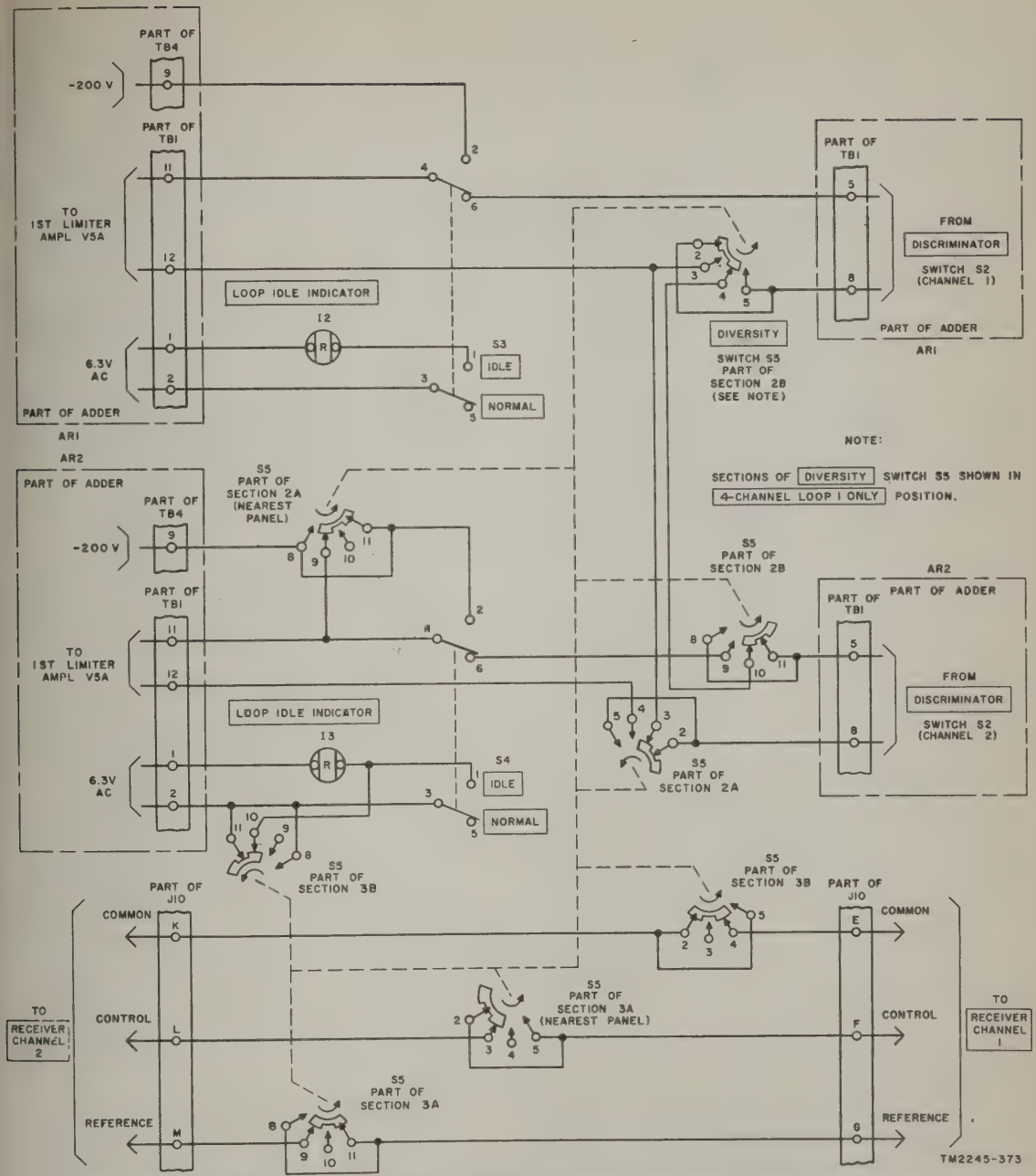
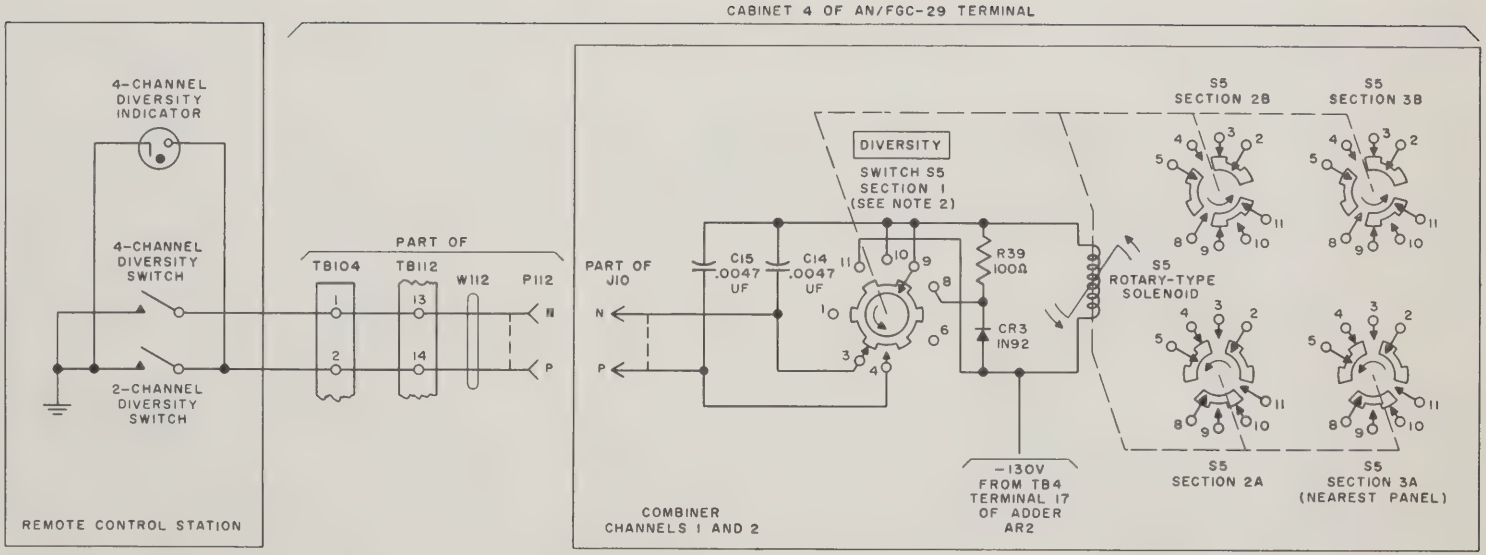



*Figure 129. Combiner, diversity switching circuits, four-channel diversity, simplified schematic diagram.*




NOTES:

1. FOR REMOTE CONTROL CIRCUIT CONNECTIONS OF ALL COMBINERS, REFER TO SCHEMATIC DIAGRAM FOR RECEIVING TERMINAL REMOTE CONTROL CIRCUITS.
2. DIVERSITY SWITCH S5 SHOWN IN 2-CHANNEL LOOPS 1 & 2 POSITION.

TM2245-393

*Figure 130. Combiner, DIVERSITY switch S5, remote switching, schematic diagram.*

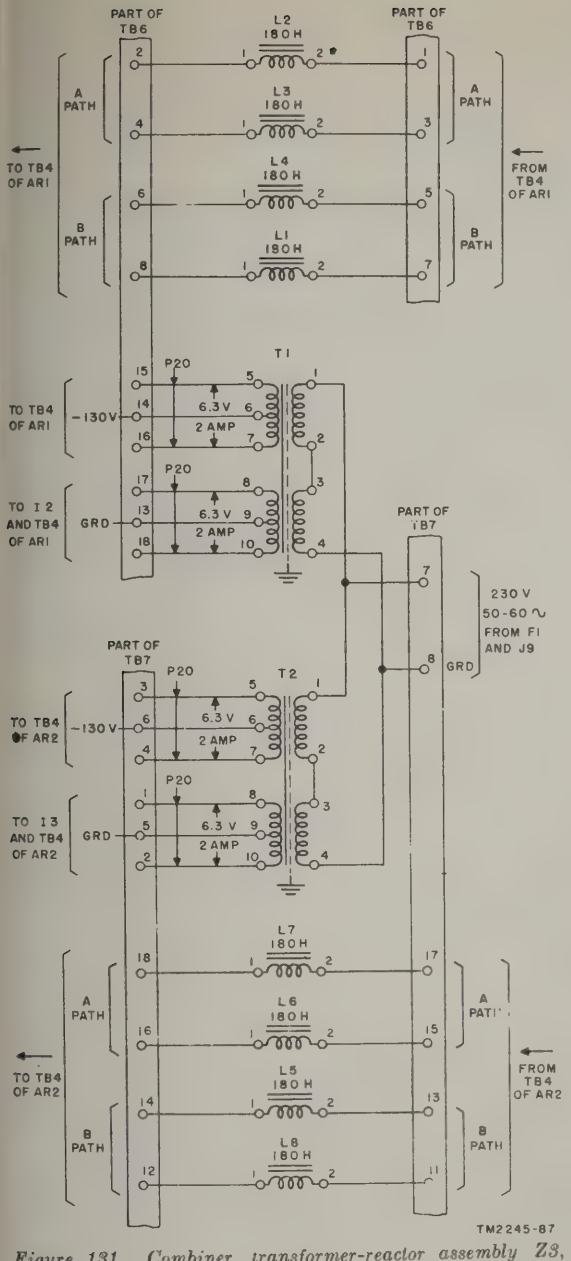



*Figure 131. Combiner, transformer-reactor assembly Z3, schematic diagram.*

tain the potential of the heaters within the heater-to-cathode voltage rating of tubes V5, V6, and V7 in adder AR1 (AR2) which are operated with negative cathode potential.

## 192. Combiner, External Power Connections

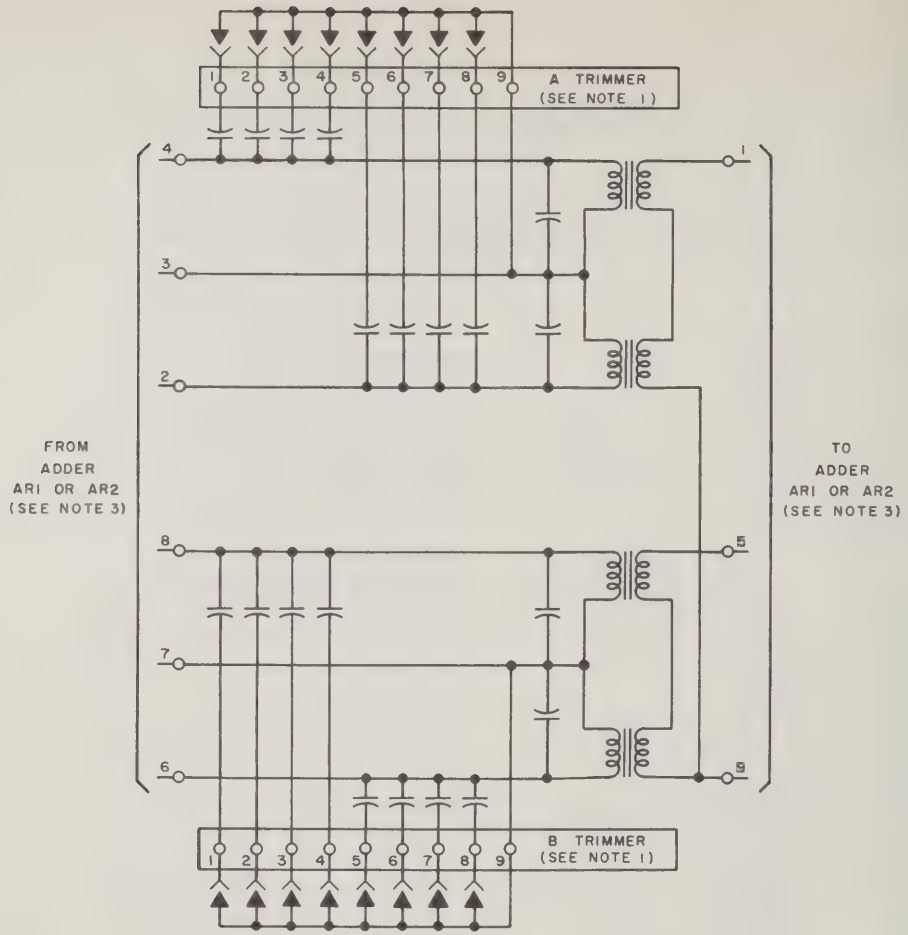
(fig. 256)

Plate voltage of +200 volts dc for A path amplifier V3 and B path amplifier V1 in adder AR1 is supplied from the channel 1 receiver to terminal 15 on terminal board TB4 of adder AR1 through terminal H on connector J10 of the combiner. Plate voltage of +200 volts dc for A path amplifier V3 and B path amplifier V1 in adder AR2 is supplied from the channel 2 receiver to terminal 15 on terminal board TB4 of adder AR2 through terminal J on connector J10 of the combiner. Loop battery voltage of −130 volts dc for first loop keyer V6 and second loop keyer V7 in adder AR1 enters the combiner at terminal C on connector J10 and is applied to terminal 17 on terminal board TB4 of adder AR1. Loop battery voltage of −130 volts dc for first loop keyer Y6 and second loop keyer Y7 in adder AR2 enters the combiner at terminal D on connector J10 and is applied to terminal 17 of terminal board TB4 of adder AR2. Power at 230 volts ac, 50 or 60 cps, for transformers T1 and T2 in transformer-reactor assembly Z3 and for rectifiers CR1 and CR2 in adders AR1 and AR2, enters the combiner through polarized connector J9. The side of the power source applied to terminal 8 on terminal board TB7 of transformer-reactor assembly Z3 is grounded (par. 191). This arrangement is necessary for proper operation of rectifiers CR1 and CR2 in adders AR1 and AR2. The high side of the power source passes through fuse F1 to terminal 7 on transformer-reactor assembly Z3 and to terminal 6 on terminal board TB1 of adders AR1 and AR2. BLOWN FUSE INDICATOR I 1 is shunted across fuse F1. When the fuse blows, full power voltage is impressed across the indicator lamp, causing it to glow.

## 193. Combiner, Theory of Discriminator

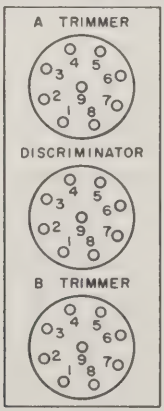
(fig. 132)

Discriminators Z1 and Z2 are hermetically sealed units, each containing discriminator networks for the A and B paths of one channel. The discriminator networks convert the A and B path frequency-shift carrier signals to amplitude-modulated carrier signals which are then demodulated by detectors V4 and V2, respectively. The discriminators accept frequency-shift signals from the A path amplifier V3 at terminal 1 and from the B path amplifier V1 at terminal 5. Plate voltage is applied at terminal 9 which is common to both paths. Amplitude-modulated signals for the A path leave the discriminator at terminals




NOTES:

1. DISCRIMINATOR AS VIEWED FROM TERMINAL END; WIRING ADDED ON TRIMMERS AS REQUIRED TO TUNE DISCRIMINATOR.




2.

| CHANNEL | DISCRIMINATOR DESIGNATION |
|---|---|
| 1 OR 16 | 1/16 1,785 CPS |
| 2 OR 15 | 2/15 2,975 CPS |
| 3 OR 14 | 3/14 1,955 CPS |
| 4 OR 13 | 4/13 2,805 CPS |
| 5 OR 12 | 5/12 2,125 CPS |
| 6 OR 11 | 6/11 2,635 CPS |
| 7 OR 10 | 7/10 2,295 CPS |
| 8 OR 9 | 8/9 2,465 CPS |

3. FOR INPUT AND OUTPUT CONNECTIONS SEE SCHEMATIC DIAGRAM OF COMBINER.

TM2245-380

*Figure 132. Combiner, discriminator, schematic diagram.*

2, 3, and 4 and pass to detector V4. Amplitude-modulated signals for the B path leave the discriminators at terminals 6, 7, and 8 and pass to detector V2. Trimmer A terminals 1 through 9 permit tuning adjustment of the A path network and trimmer B terminals 1 through 9 permit tuning adjustment of the B path network. Figure 132 is a schematic diagram which shows the internal configuration of the discriminators and lists their channel designations and frequencies.

## Section IX. THEORY OF MULTIPLEXER TD–97/FGT–2, DEMULTIPLEXER TD–98/FGR–3, AND AUDIOFREQUENCY AMPLIFIER AM–911/FG

### 194. General

Two multiplexers, three demultiplexers, and four audiofrequency amplifiers are furnished as part of the AN/FGC–29 terminal. The multiplexers and demultiplexers are used to derive two 3-kc vf facilities from each 6-kc radio channel. The audiofrequency amplifiers are used to equalize the wire line circuits interconnecting the radio transmitter and receiver sites with the AN/FGC–29 terminal. These components can be used either in the AN/FGC–29 terminal or at the radio stations.

### 195. Multiplexer TD–97/FGT–2, Block Diagram Analysis

The signal paths of Multiplexer TD–97/FGT–2 are shown on the block diagram (fig. 133). For a detailed analysis of the multiplexer circuit, refer to the TM 11–2265 for the multiplexer.

*a. Direct Path.* Transformer T12 is the input transformer for the direct path of the multiplexer. Signals in the frequency range from 375 to 3,025 cps are fed to the input of the multiplexer from the telegraph transmitter group or from a telephone or facsimile circuit either directly or over interconnecting line facilities. These input signals are applied through transformer T12 to attenuator AT1, both of which are located in input coupler Z2. Attenuator AT1 is a 23-db fixed pad inserted in the direct path of the multiplexer to make its transmission loss equal to that of the translated path. Following attenuator AT1 is mux filter 3 with a pass band from 300 to 3,100 cps. Mux filter 3 passes the signal frequencies but removes any low-frequency noise, signal harmonics, or other spurious frequencies that may be present. The output of this band-pass filter is transformer coupled to LEVEL ADJUST control AT2, which is a 50-db attenuator adjustable in 1-db steps. Attentuator AT2 is used to adjust the signal level applied to the input of line amplifier AR1 and thereby to control the level at the output of the multiplexer. Line amplifier AR1 has a fixed gain of 50 db. It raises the level of the signals and delivers them to the multiplexer output, after which they are fed to the radio transmitter.

*b. Translated Path.* Signals for the translated path of the multiplexer pass from the telegraph transmitter group or from a telephone or facsimile circuit to input transformer T13, located in input coupler Z2. Following transformer T13 is mux filter 1 with a band-pass filter and a 4-db pad. The filter pass band from 300 to 3,100 cps passes the signal frequencies from 375 to 3,025 cps but removes any low-frequency noise, signal harmonics, or other spurious frequencies that may be present. The output of the band-pass filter is fed through the 4-db pad which reduces the signal level to a value suitable for the input of modulator Z1, which follows. In modulator Z1, a carrier frequency of 6,290 cps provided by carrier supply Y1 is modulated by the signal frequencies from 375 to 3,025 cps. The upper sideband resulting from the modulation process occupies a band of frequencies between 6,665 and 9,315 cps, and the lower sideband extends from 3,265 to 5,915 cps. The carrier frequency and the input signal frequencies are suppressed by balance within the modulator and do not appear at its output. The upper and lower sideband frequencies are fed from modulator Z1 to mux filter 2 where a 10-db pad provides the correct terminating impedance for modulator Z1 and acts as a buffer between the modulator and the band-pass filter that follows. This filter has a pass band from 3,200 to 6,100 cps that transmits the lower sideband frequencies and rejects the upper sideband. The translated path signals appearing at the output of mux filter 2 are combined with the direct path signals in mux filter 3. The combined signal frequencies extending from 375 to 5,915 cps are then transmitted to the output of the multiplexer as described in *a* above.

*c. Power Supply.* Plate supply PS1 furnishes the heater voltage and B-plus voltage required for the operation of line amplifier AR1 and carrier supply Y1 of the multiplexer. Input power for plate supply PS1 is 115 or 230 volts ac at 50 or 60

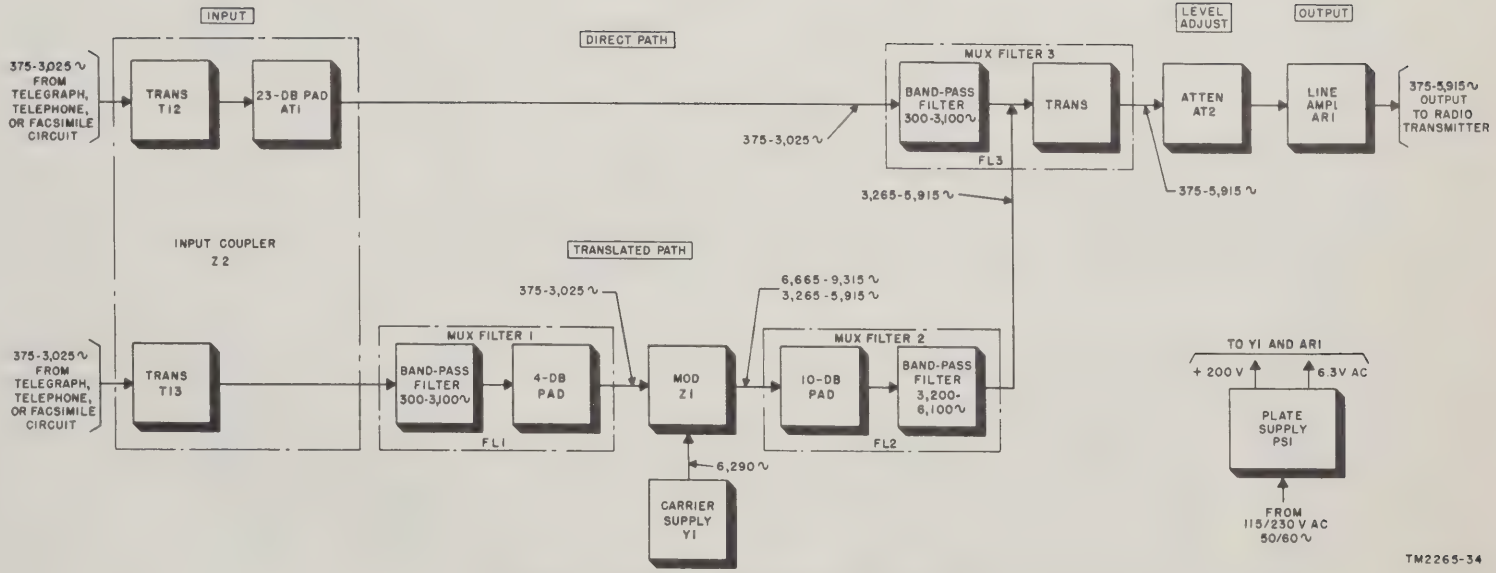



*Figure 133. Multiplexer TD-97/FGT-2, block diagram.*

cps. Its output provides a B-plus voltage of 200 volts dc and a heater voltage of 6.3 volts ac.

## 196. Demultiplexer TD–98F/GR–3, Block Diagram Analysis

The signal paths of Demultiplexer TD–98/FGR–3 are shown on the block diagram (fig. 134). The power supply for the demultiplexer is covered in *c* below. For a detailed analysis of the demultiplexer circuit, refer to the manual for the demultiplexer.

*a. Direct Path.* Transformer T12 is the input transformer to the demultiplexer. Signals in the frequency range from 375 to 5,915 cps are sent from a radio receiver either directly, or over interconnecting lines, through transformer T12 to INPUT LEVEL ADJUST control AT1. Attenuator AT1 is a 50-db variable attenuator, adjustable in 1-db steps, used to reduce the incoming signal level when it exceeds the correct input level for the demultiplexer. Following attenuator AT1 is demux filter 1 which contains a transformer, a low-pass filter, and a 23-db pad. The incoming signals are transformer coupled to the low-pass filter which has a cutoff frequency of 3,150 cps. This filter passes signals for the direct path of the demultiplexer and blocks signals for the translated path. It accepts the 375- to 3,025-cps band of frequencies and rejects the 3,265- to 5,915-cps band. The accepted frequencies enter the 23-db pad which makes the transmission loss of the direct path equal to that of the translated path. The signals then pass to the DIRECT PATH OUTPUT LEVEL ADJUST control AT2 which is a 50-db attenuator adjustable in 1-db steps. Attenuator AT2 is used to adjust the signal level applied to the input of line amplifier AR1 which follows, and thereby to control the level at the output of the demultiplexer. Line amplifier AR1 has a fixed gain of 50 db. It raises the level of the signals and delivers them to the direct path output of the demultiplexer, after which they are fed to the appropriate telephone, telegraph, or facsimile circuit.

*b. Translated Path.* After passing through transformer T12, and INPUT LEVEL ADJUST control AT1, the signals for the translated path are blocked by the low-pass filter in demux filter 1, and travel to demux filter 2. Demux filter 2 contains a 3,200- to 6,100-cps band-pass filter and a 6-db pad. The band-pass filter passes the 3,265- to 5,915-cps signals and rejects the 375- to 3,025-cps signals. The 6-db pad reduces the signal level to a value suitable for the input of modulator Z1 which follows. In modulator Z1 a carrier of 6,290 cps, supplied by carrier supply Y1, is modulated by the 3,265- to 5,915-cps signals. The upper sideband produced by the modulation process occupies a band between 9,555 and 12,205 cps, and the lower sideband extends from 375 to 3,025 cps. The carrier and input frequencies are suppressed by balance within the modulator and do not appear at its output. The upper and lower sideband frequencies are fed from modulator Z1 to demux filter 3 where an 8-db pad provides the correct terminating impedance for modulator Z1 and acts as a buffer between the modulator and the low-pass filter which follows. This low-pass filter has a cutoff frequency of 3,200 cps which allows passage of the lower sideband frequencies but rejects the upper sideband. The 375- to 3,025-cps signals are passed to TRANSLATED PATH OUTPUT LEVEL ADJUST control AT3. Attenuator AT3 is used to adjust the signal level applied to the input of line amplifier AR2 which follows, and thereby to control the level at the output of the demultiplexer. Line amplifier AR2 raises the level of the signals and delivers them to the translated path output of the demultiplexer, after which they are fed to the appropriate telephone, telegraph, or facsimile circuit.

*c. Power Supply.* Plate supply PS1 furnishes the heater voltage and B-plus voltage required for the operation of line amplifiers AR1 and AR2 and carrier supply Y1 of the demultiplexer. Input power for plate supply PS1 is 115 or 230 volts ac at 50 or 60 cps. Its output provides a B-plus voltage of 200 volts dc and a heater voltage of 6.3 volts ac.

## 197. Audiofrequency Amplifier AM–911/FG, Block Diagram Analysis

(fig. 135)

The two transmission paths, designated as AMPLIFIER A and AMPLIFIER B, of Audiofrequency Amplifier AM–911/FG are shown on the block diagram (fig. 135). The power supply for the audiofrequency amplifier is discussed in *c* below. For a detailed circuit analysis of the audiofrequency amplifier, refer to the manual for the audiofrequency amplifier.

*a. AMPLIFIER A.* Signals for the input of AMPLIFIER A enter input 1 and are applied to line matching transformer T4 which is located in line transformer assembly Z1. Transformer T4

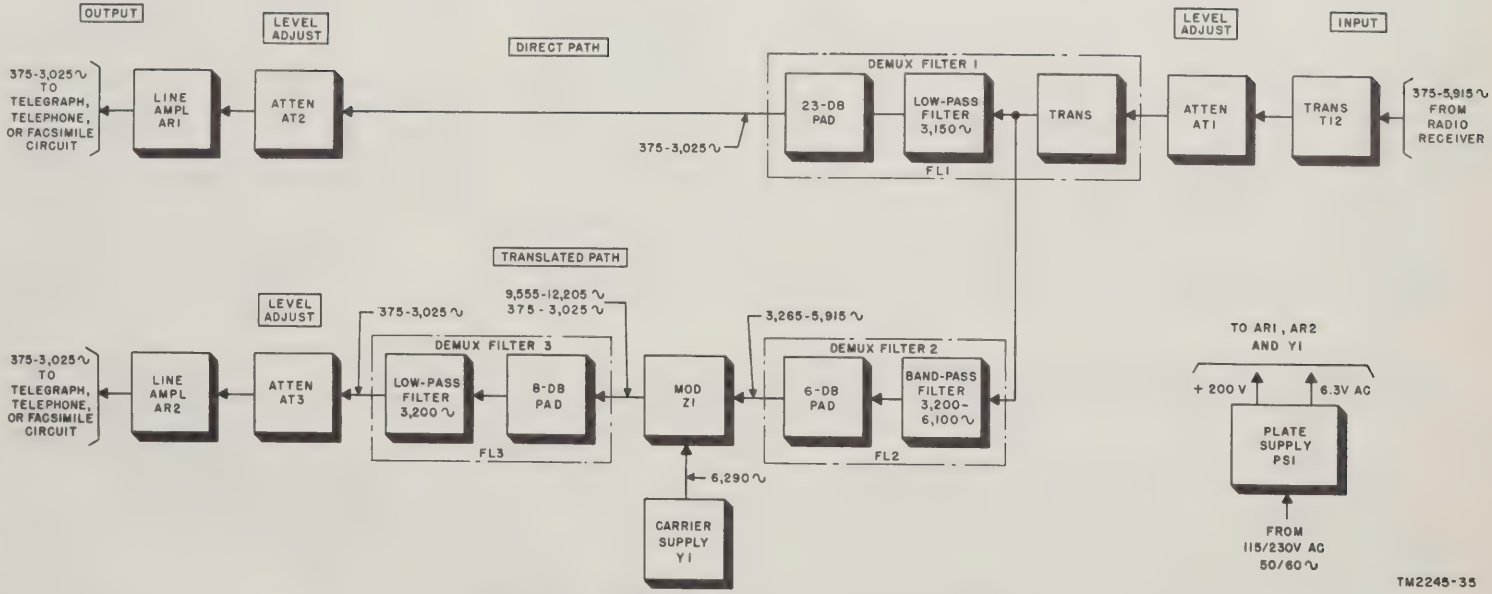



*Figure 184. Demultiplexer TD–98/FGR–3, block diagram.*

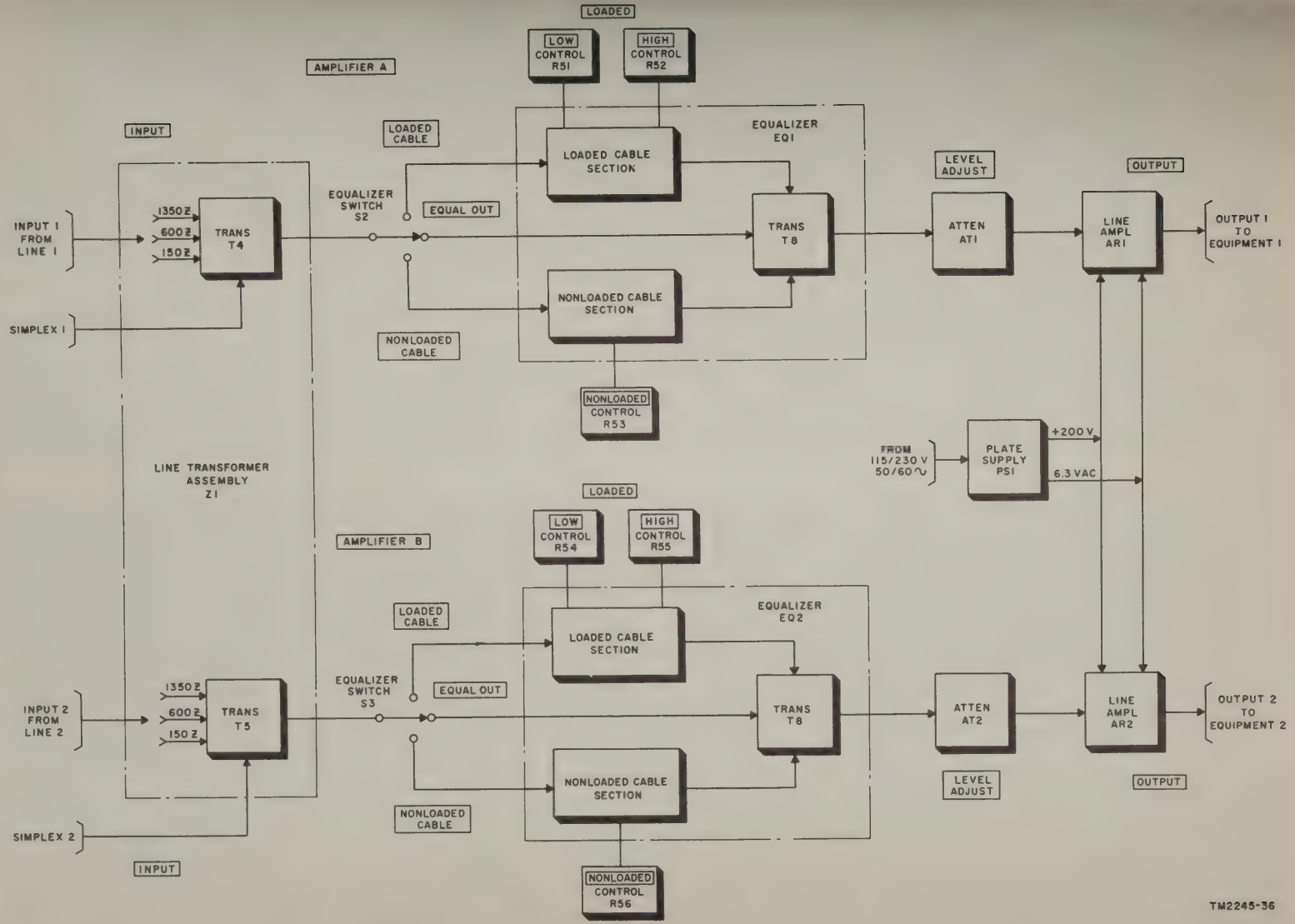



*Figure 135. Audiofrequency Amplifier AM-911/FG, block diagram.*

has an input impedance of 150, 600, or 1,350 ohms. A simplex connection is also provided on transformer T4. The output of transformer T4 passes to equalizer switch S2 which dettrmines the path the signals will take through equalizer EQ1 of AMPLIFIER A. When switch S2 is in the EQUAL OUT position, the signals are fed directly to transformer T8 without receiving any equalization. When switch S2 is in the NONLOADED CABLE position, the signals are fed to the nonloaded cable section of equalizer EQ1 where the compensation for loss in nonloaded cable takes place. The NONLOADED control, variable resistor R53, varies the frequency response of the nonloaded cable section. After equalization, the signals are fed to transformer T8. When switch S2 is in the LOADED CABLE position, the signals are routed to the loaded cable section of the equalizer where compensation for the loss characteristic of the loaded cable takes place. The LOADED LOW and LOADED HIGH controls, variable resistors R51 and R52, vary the low-frequency and high-frequency responses of the loaded cable section. After equalization, the signals are fed to transformer T8. The signals from transformer T8 arrive at LEVEL ADJUST control AT1. This is a 50-db attenuator adjustable in 1-db steps, which controls the input level to line amplifier AR1 and thereby the output level of AMPLIFIER A. The line amplifier supplies a flat gain of 50 db and delivers the amplified signals to output 1 of the audiofrequency amplifier.

*b. AMPLIFIER B.* Signals for the input of AMPLIFIER B enter input 2 and are applied to line matching transformer T5 which is located in line transformer assembly Z1. Transformer T5 has an input impedance of 150, 600, or 1,350 ohms. A simplex connection is also provided in transformer T5. The output of transformer T5 passes to equalizer switch S3 which determines the path the signals will take through equalizer EQ2 of AMPLIFIER B. When switch S3 is in the EQUAL OUT position, the signals are fed directly to transformer T8 without receiving any equalization. When switch S3 is in the NONLOADED CABLE position, the signals are fed to the nonloaded cable section of equalizer EQ2 where the compensation for loss in nonloaded cable takes place. The NONLOADED control, variable resistor R56, varies the frequency response of the nonloaded cable section. After equalization, the signals are fed to transformer T8. When switch S3 is in the LOADED CABLE position, the signals are routed to the loaded cable section of the equalizer where compensation for the loss characteristic of the loaded cable takes place. The LOADED LOW and LOADED HIGH controls, variable resistors R54 and R55, vary the low-frequency and high-frequency responses of the loaded cable section. After equalization, the signals are fed to transformer T8. The signals from transformer T8 arrive at LEVEL ADJUST control AT2. This is a 50-db attenuator adjustable in 1-db steps which controls the input level to line amplifier AR2 and thereby the output level of AMPLIFIER B. The line amplifier supplies a flat gain of 50-db and delivers the amplified signals to output 2 of the audiofrequency amplifier.

*c. Power Supply.* Plate Supply PS1 furnishes the heater voltage and B-plus voltage required for the operation of line amplifiers AR1 and AR2 of the audiofrequency amplifier. Input power for plate supply PS1 is 115 or 230 volts ac at 50 or 60 cps. Its output provides a B-plus voltage of 200 volts dc and a heater voltage of 6.3 volts ac.

## Section X. THEORY OF TRANSMITTING TERMINAL

### 198. General

The theory discussion in this section covers the transmitting terminal arranged for two typical system applications. The transmitting terminal arranged for operation over 6-kc line facilities to the radio transmitter site is discussed in paragraph 199, and over 3-kc line facilities in paragraph 200.

### 199. Transmitting Terminal, 6-Kc Lines, Schematic Diagram Analysis

Figure 136 shows the transmitting terminal arranged for operation over 6-kc interconnecting line facilities. Multiplexers 1 and 2 are installed in cabinet 1. The audiofrequency amplifiers mounted in cabinet 1 are not used in this application.

*a. Telegraph Transmitter Group.* Telegraph signals from 16 telegraph loops are brought into cabinet 2. The dc telegraph signals are applied to their respective transmitter channels through terminal boards TB101 through TB104. Connections to these terminal boards for the 16 transmitting loops are made as described in paragraph 52*a*. Signals from the odd-numbered

loops enter the odd channels of the transmitters through terminal 1 of terminal board TB113 through TB120, associated cables W113 through W120, terminal A of plugs P113 through P120, and connector J16 in each transmitter. Signals from the even-numbered loops enter the even channels of the transmitters through terminal 2 of terminal boards TB113 through TB120, associated cables W113 through W120, terminal B of plugs P113 through P120 and connector J16 in each transmitter. Transmitter ground is furnished for both channels through terminal 5 of terminal boards TB 113 through TB120, associated cables W113 through W120, and terminal E of plugs P113 through P120 and connector J16 in each transmitter. In the transmitter the dc loop signals control the frequency of a carrier oscillator to produce frequency-shift marking and spacing telegraph signals. The frequency-shift signals from the odd-numbered channels of the transmitters leave by way of terminal J of connectors J16 and plugs P113 through P120, associated cables W113 through W120, and terminal 7 of terminal boards TB113 through TB120 and are applied to the odd channel send bus. Frequency-shift signals from the even-numbered channels of the transmitters leave by way of terminal K of connectors J16 and plugs P113 through P120, associated cables W113 through W120, and terminal 8 of terminal boards TB113 through TB120 and are applied to the even-channel send bus. Signals from the odd-channel send bus are applied to the SUBGROUP MODULATOR through terminal 7 of terminal board TB112, cable W112, and terminal G of plug P112 and connector J23. Signals from the even-channel send bus are applied through terminal 8 of terminal boards TB112, cable W112, and terminal H of plug P112 and connector J23. Ground is supplied to the SUBGROUP MODULATOR from terminal 6 of terminal board TB112, cable W112, and terminal F of plug P112 and connector J23. The odd-numbered channel signals are passed through the SUBGROUP MODULATOR without frequency translation and the even channels are translated to a lower frequency range (par. 155). The combined signals leave the SUBGROUP MODULATOR at terminals A and B of connector J23 and plug P112 and pass through cable W112, terminals 1 and 2 of terminal boards TB112 and TB 111, cable W111, and plug P111 to terminals A and B of connector J18 in the LEVEL CONTROL & PLATE SUPPLY. Ground for the LEVEL CONTROL & PLATE SUPPLY is brought in from terminal G of connector J23 and plug P111 through cable W111 and terminal 7 of terminal board TB111. In the LEVEL CONTROL & PLATE SUPPLY, the signals are raised to the required level for transmission. The signals leave at terminals C and D of connector J18, and plug P111, and pass through cable WIII, terminals 3 and 4 of terminal board TB111, terminals 7 and 8 of terminal boards TB108, to connector J5 at terminals T and U (which are the output terminals of the telegraph transmitter group).

*b. Multiplexing Circuits.* The signals from the telegraph transmitter group (cabinet 2) are passed to cabinet 1 by way of terminals T and U of plugs P152 and P151 of intercabinet cable assembly W151 No. 1 and connector J3 in cabinet 1. In cabinet 1, these signals are applied to JACK GROUP 1 of the 3KC SEND BAND TEST PANEL through terminals 7 and 8 of terminal board TB106 and terminals 1 and 2 of terminal board TB2. Three vf telephone or facsimile circuits are connected to the transmitting terminal at terminal board TB102. One such circuit is connected at terminals 1 and 2 for jack group 2, a second to terminals 3 and 4 for jack group 3, and a third to terminals 5 and 6 for jack group 4. The 3KC SEND BAND TEST PANEL provides a central test position for monitoring or patching all four 3-kc vf circuits. For details of the jack arrangement, refer to the schematic diagram of the 3KC SEND BAND TEST PANEL (fig. 139). Signals are applied to jack group 2 at terminals 5 and 6 of terminal board TB2, and to jack group 3 and jack group 4 at terminals 3 and 4 and terminals 5 and 6, respectively, of terminal board TB3. Signals from jack group 1 leave the 3KC SEND BAND TEST PANEL at terminals 3 and 4 and from jack group 2 at terminals 7 and 8 of terminal board TB2, passing through terminals 1 and 2, and terminals 3 and 4, respectively, of terminal board TB116, cable W116, terminals A and B, and terminals C and D, repsectively of, plug P116 to like terminals of connector J23 of multiplexer No. 1. Ground is brought to the multiplexer through terminal 13 of terminal board TB116, cable W116, plug P116, and terminal N of connector J23. Signals from jack group 3 leave the 3KC SEND BAND TEST PANEL at terminals 3 and 4 and from jack group 4 at terminals 7 and 8 of terminal board TB3, and pass through terminals 1 and 2 and terminals 3 and 4, respectively, of terminal

board TB117, cable W117, terminals A and B, and terminals C and D, respectively, of plug P117 to like terminals on connector J23 in multiplexer 2. Ground is brought to the multiplexer through terminals 13 on terminal board TB117, cable W117, plug P117, and terminal N of connector J23. Cross connections are used for routing signals between the two multiplexers, depending on the system application. The routing options are discussed in paragraphs 54 and 56 and shown in figures 38 and 40. For details of the cross-connecting circuits, refer to the schematic diagram (fig. 257) and TM 11–2265 for the multiplexer. Connections are made from terminals J, K, L, and M of connector J23 in multiplexer 1 to the corresponding terminals in multiplexer 2, by means of cables W116 and W117, and terminals 9 through 12, respectively, of terminal boards TB116 and TB117. In each multiplexer, the two 3-kc vf input signals are combined into one 6-kc band suitable for transmission over one sideband of a twin-channel, single-sideband, radio transmitter. Signals leave multiplexer 1 by way of terminals E and F of connector J23 and plug P116, pass through cable W116, and terminals 5 and 6 of terminal board TB116, to Transformer Assembly TF–206/FG at terminals 9 and 10 of terminal board TB1. Signals from multiplexer 2, leave the multiplexer at terminals E and F of connector J23 and plug P117 and are applied through cable W117 and terminals 5 and 6 of terminal board TB117 to terminals 13 and 14 of terminal board TB1 of Transformer Assembly TF–206/FG. Transformer Assembly TF–206/FG provides facilities for matching the 600-ohm output impedance of the multiplexers to the impedance of the interconnecting line facilities. Signals from multiplexer 1 are applied to transformer T1 at primary terminals 1 and 4, and signals from multiplexer 2 are applied to transformer T3 at primary terminals 1 and 4. Secondary terminals 7 and 10 of transformer T1 connect to terminals 21 and 22 on terminal board TB1. In figure 136 the 150-ohm secondary terminals, 21 and 22, are shown strapped to terminals 24 and 25 at terminal board TB1 to match the 600-ohm output impedance of the multiplexer to the impedance of the 6-kc nonloaded cable. Other impedance matching connections are possible as described in paragraph 53. Similarly, 150-ohm terminals 37 and 38 associated with transformer T3 are shown strapped to terminals 40 and 41 of terminal board TB1. The output signals from multiplexer 1 at terminals 24 and 25 pass through terminals 1 and 2 of terminal board TB1 and enter line 1 at terminals 1 and 2 of terminal board TB101. Similarly the output signals from multiplexer 2 at terminals 40 and 41 pass through terminals 5 and 6 of terminal board TB1 and enter line 2 at terminals 5 and 6 of terminal board TB101. Two simplex connections for dc signaling equipment are available. Connections are made through terminal 1 of terminal board TB103 and terminal 17 of terminal board TB1 to the midpoint (terminals 8 and 9) of transformer T1 for simplex 1, and through terminal 3 of terminal board TB103 and terminal 19 of terminal board TB1 to the midpoint of transformer T3 for simplex 3.

*Figure 136. Transmitting terminal arranged for 6-kc operation, schematic diagram.*

(Contained in separate envelope)

## 200. Transmitting Terminal, 3-Kc Lines, Schematic Diagram Analysis

Figure 137 shows the transmitting terminal arranged for operation over 3-kc interconnecting line facilities. The multiplexers, and both audio-frequency amplifiers are removed from cabinet 1 and installed at the radio transmitter site. Dummy circuit panels 1 and 2 replace multiplexers 1 and 2.

*a. Telegraph Transmitter Group.* The schematic diagram analysis of the telegraph transmitter group arranged for operation with 3-kc interconnecting line facilities is identical with the analysis for operation with 6-kc line facilities (par. 199*a*).

*b. Voice-Frequency Circuits.* Signals from the telegraph transmitter group and from three vf telephone or facsimile circuits enter cabinet 1 and pass through the 3KC SEND BAND TEST PANEL in the same way when the transmitting terminal is used with 3-kc line facilities as when used with 6-kc facilities (par. 99*b*). Signals from the telegraph transmitter group appearing at terminals 3 and 4 of terminal board TB2 of the 3KC SEND BAND TEST PANEL pass through dummy circuit panel 1 from terminals 1 and 2 to terminals 5 and 6 of terminal board TB116, entering by way of cable W116, and terminals A and B of plug P116 and connector J2, and leaving through terminals E and F of the same plug and connector. The signal path for the vf signals from terminals 7 and 8 of terminal board TB2 is cut through dummy circuit panel 1 from terminals

3 and 4 to terminals 7 and 8 of terminal board TB116, entering by way of cable W116, terminals C and D of plug P116 and connector J2, and leaving through terminals G and H of the same plug and connector. The vf signals from terminals 3 and 4 of terminal board TB3 are cut through dummy circuit panel 2 from terminals 1 and 2 to terminals 5 and 6 of terminal board TB117, entering by way of cable W117 and terminals A and B of plug P117 and connector J2, and leaving through terminals E and F of the same plug and connector. Vf signals from terminals 7 and 8 of terminal board TB3 are cut through dummy circuit panel 2 from terminals 3 and 4 to terminals 7 and 8 of terminal board TB117, entering by way of cable W117, and terminals C and D of plug P117 and connector J2, and leaving through terminals G and H of the same plug and connector. Signals for line 1 are applied to primary terminals 1 and 4 of transformer T1 through terminals 9 and 10 of terminal board TB1 on Transformer Assembly TF–206/FG. Signals for line 2 are applied to primary terminals 1 and 4 of transformer T2 through terminals 11 and 12 of terminal board TB1. Signals for line 3 are similarly applied to transformer T3 through terminals 13 and 14, and for line 4, to transformer T4 through terminals 15 and 16 of terminal board TB1. Transformers T1 through T4 have primary impedances of 600 ohms and are shown in figure 137 with line connections strapped to 600-ohm secondary terminals 6 and 11 to match the impedance of the loaded cable pairs. Secondary impedance of 150 and 1,350 ohms are available when required and are selected as described in paragraph 53. Signals from transformer T1 pass through terminals 23 and 26 strapped to terminals 24 and 25, to terminals 1 and 2 of terminal board TB1 and are applied to line 1 through terminals 1 and 2 of terminal board TB101. Signals from transformer T2 pass through terminals 31 and 34 strapped to terminals 32 and 33, to terminals 3 and 4 of terminal board TB1 and are applied to line 2 through terminals 3 and 4 of terminal board TB101 Signals from transformer T3 pass through terminals 39 and 42 strapped to terminals 40 and 41, continue to terminals 5 and 6 of terminal board TB1 and are applied to line 3 through terminals 5 and 6 of terminal board TB101. Signals from transformer T4 pass through terminals 47 and 50 strapped to terminals 48 and 49; continue to terminals 7 and 8 of terminal board TB1, and are applied to line 4 through terminals 7 and 8 of terminal board TB101. Four simplex connections for dc signaling equipment are available on terminal board TB103 at terminals 1 through 4, which connect to the midpoints of the secondary windings of transformers T1 through T4, respectively, by way of terminals 17 through 20 on terminal board TB1 of Transformer Assembly TF–206/FG.

*Figure 137. Transmitting terminal, arranged for 3-kc operation, schematic diagram.*

(Contained in separate envelope)

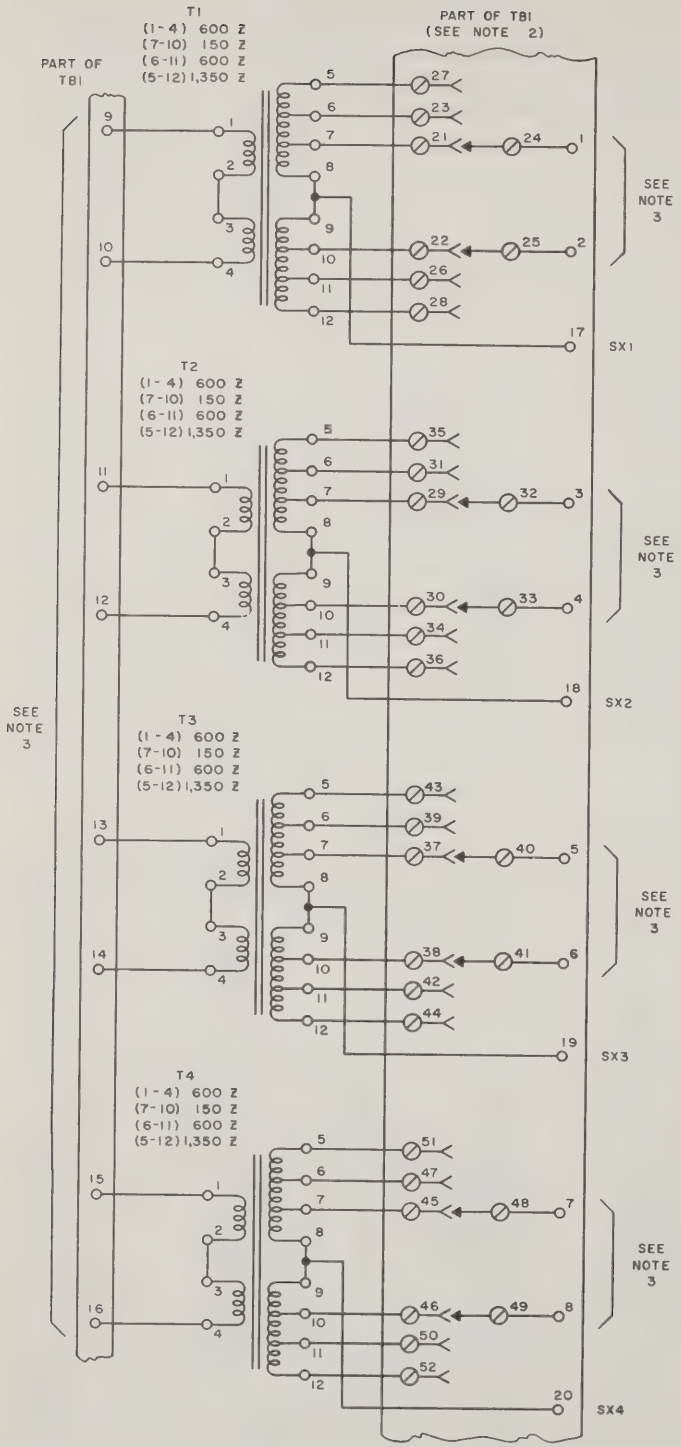
## 201. Theory of Transformer Assembly TF–206/FG

(fig. 138)

Transformer Assembly TF–206/FG contains four line-matching transformers for matching the impedance of the transmitting or receiving terminal to that of the 3- or 6-kc line facilities. Three impedances (150, 600, or 1,350 ohms), are available on transformers T1 through T4 for matching up to four lines. These impedances are selected for various types of lines (par. 42) by making the strapping connections described in paragraph 53. A simplex connection is available at the center tap on the line-side winding of each transformer. Figure 138 is a schematic diagram of Transformer Assembly TF–206/FG.

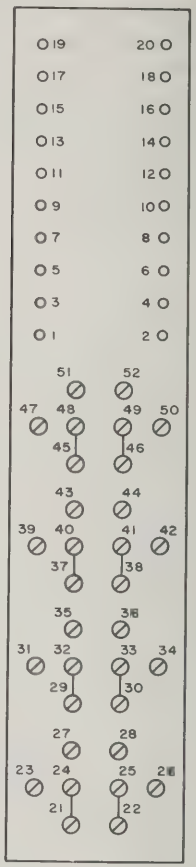
## 202. Theory of 3KC SEND BAND TEST PANEL

The 3KC SEND BAND TEST PANEL provides a central position in the transmitting terminal for monitoring and patching the vf circuits to be transmitted. The panel contains four jack groups (jack group 1 through jack group 4) to permit monitoring or patching of four 3-kc signal bands (par. 200). Each jack group contains a LINE IN, an EQUIP OUT, and a MONITOR, jack pair. The EQUIP OUT jacks allow measurement of the outgoing signal level and permit the signals to be patched to the LINE IN jacks of a different vf circuit. The LINE IN jacks allow the introduction of test signals into the outgoing line facilities, and permit the lines to be patched to the EQUIP OUT jacks of a different vf circuit. The MONITOR jacks are connected across the signal path immediately following the LINE IN jacks and permit monitoring of the outgoing vf signals. The 3KC SEND BAND TEST PANEL also contains eight trunk jack pairs (TRUNK 1 through TRUNK 8) which connect to terminal boards TB103 and TB104 of cabinet 1 of the




NOTES:

1. IMPEDANCES ARE IN OHMS.
2. TERMINAL BOARD TB1 AS VIEWED FROM FRONT. WIRING ADDED AS REQUIRED (SEE TABLE BELOW) TO MATCH LINE IMPEDANCE.

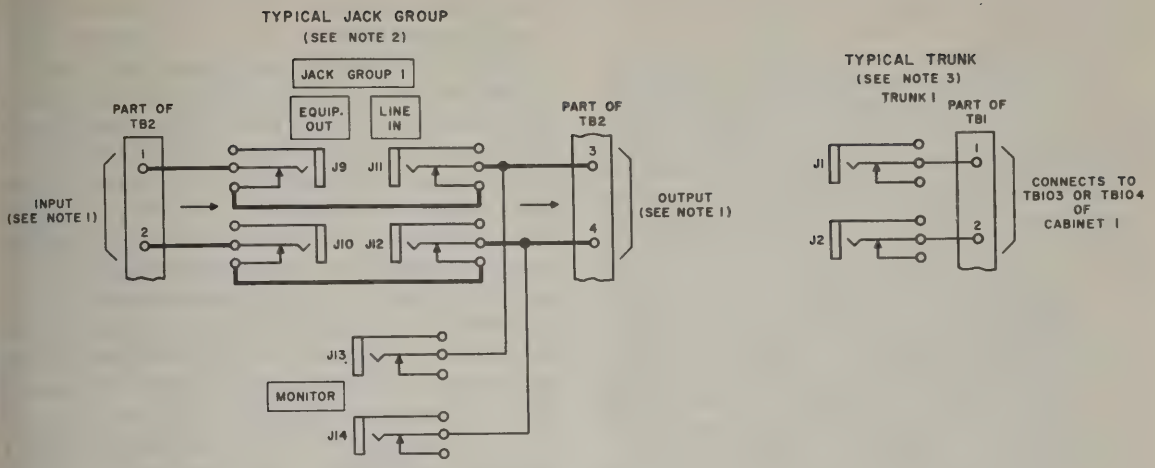



| TRANSFORMER | IMPEDANCE | CONNECT |
|---|---|---|
| T1 | 150 | 24 TO 21, 25 TO 22 |
| T2 | 150 | 32 TO 29, 33 TO 30 |
| T3 | 150 | 40 TO 37, 41 TO 38 |
| T4 | 150 | 48 TO 45, 49 TO 46 |
| T1 | 600 | 24 TO 23, 25 TO 26 |
| T2 | 600 | 32 TO 31, 33 TO 34 |
| T3 | 600 | 40 TO 39, 41 TO 42 |
| T4 | 600 | 48 TO 47, 49 TO 50 |
| T1 | 1,350 | 24 TO 27, 25 TO 28 |
| T2 | 1,350 | 32 TO 35, 33 TO 36 |
| T3 | 1,350 | 40 TO 43, 41 TO 44 |
| T4 | 1,350 | 48 TO 51, 49 TO 52 |

3. FOR INPUT AND OUTPUT CONNECTIONS REFER TO SCHEMATIC DIAGRAMS OF TRANSMITTING AND RECEIVING TERMINALS.

TM2245-375

*Figure 138. Transformer Assembly TF-206/FG, schematic diagram.*




NOTES:

1. FOR INPUT AND OUTPUT CONNECTIONS REFER TO SCHEMATIC DIAGRAM OF TRANSMITTING TERMINAL.
2. REFERENCE SYMBOLS FOR ALL JACK GROUPS APPEAR IN TABLE BELOW.

| JACK GROUP | JACK LABEL | JACK REF SYMBOL | CONNECTS TO | |
|---|---|---|---|---|
| | | | TERMINAL BOARD | TERMINAL NO. |
| 1 | EQUIP. OUT | J9 | TB2 | 1 |
| | | J10 | TB2 | 2 |
| | LINE IN | J11 | TB2 | 3 |
| | | J12 | TB2 | 4 |
| | MONITOR | J13 | —— | —— |
| | | J14 | —— | —— |
| 2 | EQUIP. OUT | J15 | TB2 | 5 |
| | | J16 | TB2 | 6 |
| | LINE IN | J17 | TB2 | 7 |
| | | J18 | TB2 | 8 |
| | MONITOR | J19 | —— | —— |
| | | J20 | —— | —— |
| 3 | EQUIP. OUT | J21 | TB3 | 1 |
| | | J22 | TB3 | 2 |
| | LINE IN | J23 | TB3 | 3 |
| | | J24 | TB3 | 4 |
| | MONITOR | J25 | —— | —— |
| | | J26 | —— | —— |
| 4 | EQUIP. OUT | J27 | TB3 | 5 |
| | | J28 | TB3 | 6 |
| | LINE IN | J29 | TB3 | 7 |
| | | J30 | TB3 | 8 |
| | MONITOR | J31 | —— | —— |
| | | J32 | —— | —— |

3. REFERENCE SYMBOLS FOR ALL TRUNKS APPEAR IN TABLE BELOW.

| TRUNK | JACK REF SYMBOL | CONNECTS TO | |
|---|---|---|---|
| | | TERMINAL BOARD | TERMINAL NO. |
| 1 | J1 | TB1 | 1 |
| | J2 | TB1 | 2 |
| 2 | J3 | TB1 | 3 |
| | J4 | TB1 | 4 |
| 3 | J5 | TB1 | 5 |
| | J6 | TB1 | 6 |
| 4 | J7 | TB1 | 7 |
| | J8 | TB1 | 8 |
| 5 | J33 | TB4 | 1 |
| | J34 | TB4 | 2 |
| 6 | J35 | TB4 | 3 |
| | J36 | TB4 | 4 |
| 7 | J37 | TB4 | 5 |
| | J38 | TB4 | 6 |
| 8 | J39 | TB4 | 7 |
| | J40 | TB4 | 8 |

TM2245-364

*Figure 139. 3KC SEND BAND TEST PANEL, schematic diagram.*

transmitting terminal to pick up general purpose trunk circuits brought to these terminal boards for patching, monitoring, or testing purposes. A typical jack group and typical trunk jack pair are shown in the schematic diagram of the 3KC SEND BAND TEST PANEL (fig. 139), with tables listing the reference symbols and terminal board connections.

## Section XI. THEORY OF RECEIVING TERMINAL

### 203. General

The theory discussion in this section covers the receiving terminal arranged for two typical system applications. The receiving terminal arranged for operation over 6-kc line facilities from the radio receiver site is discussed in paragraph 204, and over 3-kc facilities in paragraph 205.

## 204. Receiving Terminal, 6-kc Lines, Schematic Diagram Analysis

(fig. 252)

The receiving terminal is shown in figure 252 arranged for operation over 6-kc interconnecting line facilities. Audiofrequency amplifiers 1 and 2 and demultiplexers 1, 2, and 3 are shown in place in cabinet 3. Demultiplexer 3 is used for space diversity applications only. The demultiplexing equipment is discussed in *a*, and the telegraph receiver group in *b* below.

*a. Demultiplexing Equipment.* Two 6-kc lines enter cabinet 3 at terminals 9 and 10 of terminal board TB101 and terminals 3 and 4 of terminal board TB102. A third 6-kc line, used to bring in the space diversity telegraph signals, connects to terminal board TB102 at terminals 7 and 8. Connections to terminal board TB103, terminals 1 and 2, are made only if additional equipment is added to the basic AN/FGC–29 terminal as described in paragraph 59. Signals from line No. 1 at terminals 9 and 10 of terminal board TB101 are applied through terminals 1 and 2 of Transformer Assembly TF–206/FG No. 1 to terminals 24 and 25. Signals from line No. 2 at terminals 3 and 4 of terminal board TB102 are applied through terminals 5 and 6 to terminals 40 and 41. In figure 252, terminals 24 and 25 are shown strapped to terminals 21 and 22, respectively, and terminals 40 and 41 are shown strapped to terminals 37 and 38, respectively. Alternative connections for different line impedances are possible as described in paragraph 53. Terminals 21 and 22 connect to the 150-ohm taps on the primary of transformer T1 at terminals 7 and 10, and terminals 37 and 38 similarly connect to the 150-ohm primary taps of transformer T3. Signals from line 3 at terminals 7 and 8 of terminal board TB102 are applied through terminals 1 and 2 on terminal board TB1 of Transformer Assembly TF–206/FG No. 2 to terminals 24 and 25, which are strapped to terminals 21 and 22. Terminals 21 and 22 connect to the 150-ohm primary taps of transformer T1 at terminals 7 and 10. Simplex connections are made at the midpoint of the primary winding of transformers T1 and T3 in both Transformer Assemblies TF–206/FG. Simplex 1 and simplex 3 are brought out from Transformer Assembly TF–206/FG No. 1 by way of terminals 17 and 19 of terminal board TB1 of the transformer assembly and terminals 1 and 3 of terminal board TB101. Simplex 5 and simplex 7 are similarly brought out from Transformer Assembly TF–206/FG No. 2 to terminals 5 and 7 of terminal board TB101. Line No. 1 signals leave Transformer Assembly TF–206/FG No. 1 at terminals 9 and 10 of terminal board TB1, and are routed through terminal board TB111, terminals 1 and 2, cable W111, and terminals A and B of plug P111 to connector J26 of audiofrequency amplifier No. 1. Line No. 2 signals leave Transformer Assembly TF–206/FG No. 1 at terminals 13 and 14 of terminal board TB1, and pass to audiofrequency amplifier 1 by way of terminals 3 and 4 of terminal board TB111, cable W111, and terminals C and D of plug P111, and connector J26. Line 3 signals leave Transformer Assembly TF–206/FG No. 2 at terminals 9 and 10 of terminal board TB1 and pass to audiofrequency amplifier No. 2 by way of terminals 1 and 2 of terminal board TB112, cable W112, and terminals A and B of plug P112 and connector J26. Ground for audiofrequency amplifier No. 1 is brought in from terminal 9 of terminal board TB111 through cable W111, and terminal J of plug P111 and connector J26. Ground for audiofrequency amplifier No. 2 is brought in from terminal 9 of terminal board TB112 through cable W112 and terminal J of plug P112 and connector J26. Line No. 1 signals leave audiofrequency amplifier No. 1 by way of terminals E and F of connector J26 and plug P111 and are applied to demultiplexer No. 1 through terminals 5 and 6 of terminal board TB111 and terminals 1 and 2 of terminal board TB116, cable W116, and terminals A and B of plug P116 and connector J23. The demultiplexer ground is brought in from terminal 9 of terminal board TB116 through cable W116 and terminal J of plug P116 and connector J23. Line No. 2 signals leave audiofrequency amplifier No. 1 at terminals G and H of connector J26 and plug P111, and are applied to demultiplexer No. 2 through terminals 7 and 8 of terminal board TB111 and terminals 1 and 2 of terminal board TB117, cable W117, and terminals A and B of plug P117 and connector J23. Ground for demultiplexer 2 is brought in from terminal 9 of terminal board TB117 through cable W117 and terminal J of plug P117 and connector J23. Line No. 3 signals leave audiofrequency amplifier No. 2 from terminals E and F of connector J26 and plug P112, and are applied to demultiplexer 3 through terminals 5 and 6 of terminal board TB112, and terminals 1 and 2 of terminal board TB118, cable W118, and terminals A and B of plug P118 and connector J23. Ground for demultiplexer 3 is

brought in from terminal 9 of terminal board TB118 through cable W118 and terminal J of plug P118 and connector J23. In each demultiplexer the 6-kc input signal band is converted into two 3-kc vf bands. In figure 252, the telegraph signals are shown leaving demultiplexer 1 by way of terminals E and F of connector J23 and plug P116, and are applied to terminals 3 and 4 on terminal board TB2 for JACK GROUP 1 of the 3KC RECEIVE BAND TEST PANEL, through cable W116 and terminals 5 and 6 of terminal board TB116. Telephone or facsimile signals in the second output of demultiplexer 1 leave by way of terminals G and H of connector J23 and plug P116, and are applied to terminals 7 and 8 on terminal board TB2, for JACK GROUP 2 of the 3KC RECEIVE BAND TEST PANEL through cable W116 and terminal board TB116, terminals 7 and 8. Telephone or facsimile signals in the first output of demultiplexer No. 2 leave at terminals E and F of connector J23 and plug P117 and are applied by way of terminals 5 and 6 of terminal board TB117, and terminals 3 and 4 of terminal board TB3, to JACK GROUP 3 of the 3KC RECEIVE BAND TEST PANEL. Telephone or facsimile signals in the second output of demultiplexer No. 2 leave by way of terminals G and H of connector J23 and plug P117 and are applied to terminals 7 and 8 on terminal board TB3 for JACK GROUP 4 of the 3KC RECEIVE BAND TEST PANEL through cable W117 and terminals 7 and 8 of terminal board TB117. Space diversity telegraph signals leave demultiplexer No. 3 at terminals E and F of connector J23 and plug P118 and are applied to terminals 3 and 4 on terminal board TB4 for JACK GROUP 5 of the 3KC RECEIVE BAND TEST PANEL by way of cable W118 and terminals 5 and 6 of terminal board TB118. The second output of demultiplexer No. 3, carrying diversity signals of the telephone or facsimile vf circuit at the second output of demultiplexer No. 1, is unused in this application. As shown in figure 252, this output from terminals G and H of connector J23 and plug P118 is connected to JACK GROUP 6 of the 3KC RECEIVE BAND TEST PANEL at terminals 7 and 8 of terminal board TB4. Connections from this jack group are brought out at terminals 5 and 6 of terminal board TB4 to terminals 5 and 6 of terminal board TB108, where they are terminated in this application. Telephone or facsimile signals from JACK GROUP 2 at terminals 5 and 6 of terminal board TB2 are made available for connection to external circuits at terminals 7 and 8 of terminal board TB107. Similarly signals from JACK GROUP 3 at terminals 1 and 2, and from JACK GROUP 4 at terminals 5 and 6, of terminal board TB3 are available at terminals 9 and 10 of terminal board TB107 and terminals 1 and 2 of terminal board TB108, respectively. The telegraph signals from JACK GROUP 1 at terminals 1 and 2 of terminal board TB2 are applied to terminals 5 and 6, which are strapped to terminals 1 and 2 of terminal board TB107. The diversity telegraph signals from JACK GROUP 5 at terminals 1 and 2 of terminal board TB4 are applied to terminals 3 and 4 of the terminal board TB108 which are strapped to terminals 3 and 4 of terminal board TB107. Two additional vf circuits from the radio receiver site can be made available if additional equibment is added to the basic AN/FGC–29 terminal (par. 59).

*b. Telegraph Receiver Group.* Signals for the A path of the telegraph receiver group leave cabinet 3 at terminals 1 and 2 of terminal board TB107 and are applied to cabinet 4 by way of terminals A and B of connector J2 and plug P152 of cable assembly W151 No. 2, and terminals A and B of plug P151 and connector J4 in cabinet 4. The signals continue through terminals 1 and 2 of terminal boards TB103 and TB105, leave cabinet 4 at terminals A and B of connector J3 and plug P152 of cable assembly W151 No. 5 and enter cabinet 5 through terminals A and B of plug P151 and connector J5. Diversity telegraph signals for the B path of the telegraph receiver group leave cabinet 3 at terminals 3 and 4 of terminal board TB107 and are applied to cabinet 4 by way of terminals C and D of connector J2 and plug P152 of cable assembly W151 No. 2 and terminals C and D of plug P151 and connector J4 in cabinet 4. The signals continue through terminals 3 and 4 of terminal boards TB103 and TB105, leave cabinet 4 at terminals C and D of connector J3 and plug P152 of cable assembly W151 No. 5, and enter cabinet 5 through terminals C and D of plug P151 and connector J5. Signals from connector J5 in cabinet 5 for the A path pass through terminals 1 and 2 of terminal boards TB107 and TB111, and cable W111 to the input of SUBGROUP DEMODULATOR A at terminals A and B of plug P111 and connector J23. Ground is brought into the SUBGROUP DEMODULATOR from terminal 9 of terminal board TB111 through cable W111 and terminal

J of plug P111 and connector J23. Here the telegraph signals of the 16 channels are divided into 2 groups of 8 channels each. One group consists of odd-numbered channels and the other of even-numbered channels; each group has the same frequency range. The odd-numbered channel signals leave the SUBGROUP DEMODULATOR A at terminal G of connector J23 and plug P111 and continue through cable W111 and terminal 7 of terminal board TB111 to the A path odd-channel receive bus. The even-channel signals leave SUBGROUP DEMODULATOR A at terminal H of connector J23 and plug P111 and continue through cable W111 and terminal 8 of terminal board TB111 to the A path even-channel receive bus. Telegraph signals from connector J5 in cabinet 5 for the B path of the telegraph receiver group are applied to SUBGROUP DEMODULATOR B through terminals 3 and 4 of terminal board TB107, terminals 1 and 2 of terminal board TB112, cable W112, and terminals A and B of plug P112 and connector J23. In the SUBGROUP DEMODULATOR the 16 telegraph channels of the B path are also divided into odd- and even-channel groups of 8 channels each. The odd-numbered channels leave SUBGROUP DEMODULATOR B at terminal G of connector J23 and plug P112 and are applied to the B path odd-channel receive bus through cable W112 and terminal 7 of terminal board TB112. The even-numbered channels leave SUBGROUP DEMODULATOR B at terminal H of connector J23 and plug P112 and are applied to the B path even-channel receive bus through cable W112 and terminal 8 of terminal board TB112. The four receiving buses are extended from cabinet 5 into both cabinets 4 and 6. The A path even and odd buses and the B path odd and even buses pass from terminals 5 through 8, respectively, of terminal board TB104 in cabinet 5 to the like-numbered terminals of terminal board TB102 in cabinet 4. The intercabinet connections are established by cable assembly No. 4 from terminals R, S, T, and U, respectively, of connector J4 and plug P151 in cabinet 5, to the corresponding terminals of plug P152 and connector J2 in cabinet 4. The buses also pass, in the same order, from terminals 5 through 8, respectively, of terminal board TB102 in cabinet 5 to the like-numbered terminals of terminal board TB106 in cabinet 6. The intercabinet connections are established by cable assembly No. 6 from terminals R, S, T, and U, respectively, of connector J2 and plug P152 in cabinet 5 to the corresponding terminals of plug P151 and connector J4 in cabinet 6.

(1) *A and R path, odd-channel receive bus.* Signals from the A path odd channel receive bus are applied to receiver channels 1, 3, and 5 in cabinet 4, channels 7 and 9 in cabinet 5, and channels 11, 13, and 15 in cabinet 6. Connections from the A path odd-channel receive bus to terminal G of connector J16 in the odd-numbered receiver channels are all made through terminal 7 of the odd-numbered receiver drawer cable terminal boards and terminal G of the associated plugs as indicated in the following table. Signals from the B path odd-channel receive bus are applied to receiver channels 1, 3, and 5 in cabinet 4, channels 7 and 9, in cabinet 5, and channels 11, 13, and 15 in cabinet 6. Connections from the B path odd-channel receive bus to terminal H of connector J16 in the odd-numbered receiver channels are all made through terminal 8 of the odd-numbered receiver drawer cable terminal boards and terminal H of the associated plugs as indicated in the following table. Ground is brought into terminal J on connector J16 of the odd-numbered channel receivers through terminal 9 of the odd-numbered receiver drawer cable terminal boards and terminal J of the associated plugs as indicated in the following chart.

| Receiver channel | Terminal board | Cable | Plug |
|---|---|---|---|
| 1 | TB111 | W111 | P111 |
| 3 | TB114 | W114 | P114 |
| 5 | TB118 | W118 | P118 |
| 7 | TB114 | W114 | P114 |
| 9 | TB118 | W118 | P118 |
| 11 | TB111 | W111 | P111 |
| 13 | TB114 | W114 | P114 |
| 15 | TB118 | W118 | P118 |

(2) *A and R path, even channel receive bus.* Signals from the A path even channel receive bus are applied to receiver channels 2, 4, and 6 in cabinet 4, channels 8 and 10 in cabinet 5, and channels 12, 14, and 16 in cabinet 6. Connections from

the A path even channel receive bus to terminal G of connector J16 in the even receiver channels are all made through terminal 7 of the even receiver drawer cable terminal boards and terminal G of the associated plugs as indicated in the following chart. Signals from the B path even-channel receive bus are applied to receiver channels 2, 4, and 6 in cabinet 4, channels 8 and 10 in cabinet 5, and channels 12, 14, and 16 in cabinet 6. Connections from the B path even-channel receive bus, to terminal H of connector J16 in the even receiver channels are all made through terminal 8 of the even receiver drawer cable terminal boards and terminal H of the associated plugs as indicated in the following chart.

| Receiver channel | Terminal board | Cable | Plug |
|---|---|---|---|
| 2 | TB113 | W113 | P113 |
| 4 | TB116 | W116 | P116 |
| 6 | TB120 | W120 | P120 |
| 8 | TB116 | W116 | P116 |
| 10 | TB120 | W120 | P120 |
| 12 | TB113 | W113 | P113 |
| 14 | TB116 | W116 | P116 |
| 16 | TB120 | W120 | P120 |

(3) *Receivers and combiners, interunit circuitry.* Each receiver automatically adjusts the A and B path signals for the particular channel for optimum combining in its associated combiner. In cabinet 4, the A and B path signals of channel 1 leave RECEIVER CHANNEL 1 at terminals A and B, respectively, of connector J16 and plug P111 and pass through cable W111 and terminals 1 and 2 of terminal board TB111 to the A and B path inputs for channel 1 of COMBINER CHANNELS 1 and 2, by way of terminals 15 and 16 of terminal board TB112, cable W112, and terminals R and S of plug P112 and connector J10. The A and B path signals of channel 2 leave RECEIVER CHANNEL 2 at terminals A and B, respectively, of connector J16 and plug P113 and pass through cable W113 and terminals 1 and 2 of terminal board TB113 to the A and B path inputs for channel 2 of COMBINER CHANNELS 1 and 2 by way of terminals 17 and 18 of terminal board TB112, cable W112, and terminals T and U of plug P112 and connector J10. The agc connections of RECEIVER CHANNEL 1 leave at terminals D, E, and F of connector J16 and plug P111 and pass through cable W111 and terminals 4, 5, and 6, respectively, of terminal board TB111 to the agc connections for channel 1 of COMBINER CHANNELS 1 and 2 by way of terminals 5, 6, and 7 of terminal board TB112, cable W112, and terminals E, F, and G of plug P112 and connector J10. The agc connections of RECEIVER CHANNEL 2 leave at terminals D, E, and F of connector J16 and plug P113 and pass through cable W113 and terminals 4, 5, and 6, respectively, of terminal board TB113 to the agc connections for channel 2 of COMBINER CHANNELS 1 and 2 by way of terminals 10, 11, and 12 of terminal board TB112, cable W112, and terminals K, L, and M of plug P112 and connector J10. Ground is brought into the combiner through terminal 14 of terminal board TB112, cable W112, and terminal P of plug P112 and connector J10. Connections between receiver channels 3 through 16 and their associated COMBINER CHANNELS 3 and 4 through COMBINER CHANNELS 15 and 16 are made identically with channels 1 and 2 above except that the reference designations of the intermediate plugs, cables, and terminal boards may be different as shows in the following chart.

| Cabinet | From | Through | | | To | Through | | |
|---|---|---|---|---|---|---|---|---|
| | Receiver channel | Plug | Cable | Terminal board | Combiner channel | Terminal board | Cable | Plug |
| 4 | 1 | P111 | W111 | TB111 | 1 | TB112 | W112 | P112 |
| 4 | 2 | P113 | W113 | TB113 | 2 | TB112 | W112 | P112 |
| 4 | 3 | P114 | W114 | TB114 | 3 | TB115 | W115 | P115 |
| 4 | 4 | P116 | W116 | TB116 | 4 | TB115 | W115 | P115 |
| 4 | 5 | P118 | W118 | TB118 | 5 | TB119 | W119 | P119 |
| 4 | 6 | P120 | W120 | TB120 | 6 | TB119 | W119 | P119 |
| 5 | 7 | P114 | W114 | TB114 | 7 | TB115 | W115 | P115 |
| 5 | 8 | P116 | W116 | TB116 | 8 | TB115 | W115 | P115 |
| 5 | 9 | P118 | W118 | TB118 | 9 | TB119 | W119 | P119 |
| 5 | 10 | P120 | W120 | TB120 | 10 | TB119 | W119 | P119 |
| 6 | 11 | P111 | W111 | TB111 | 11 | TB112 | W112 | P112 |
| 6 | 12 | P113 | W113 | TB113 | 12 | TB112 | W112 | P112 |
| 6 | 13 | P114 | W114 | TB114 | 13 | TB115 | W115 | P115 |
| 6 | 14 | P116 | W116 | TB116 | 14 | TB115 | W115 | P115 |
| 6 | 15 | P118 | W118 | TB118 | 15 | TB119 | W119 | P119 |
| 6 | 16 | P120 | W120 | TB120 | 16 | TB119 | W119 | P119 |

(4) *Combiners and loops, interunit circuitry.* In each combiner the A and B path frequency-shift signals from an odd-numbered receiver are converted to dc telegraph signals and combined to operate an odd-numbered receiving telegraph loop. The A and B path frequency-shift signals from an even-numbered receiver are also converted to dc telegraph signals and combined to operate an even-numbered receiving telegraph loop. The signals for the odd-numbered telegraph loops leave the combiners at terminal A and for the even-numbered loops at terminal B of connectors J10 in each combiner, and enter mating plugs P112, P115, and P119 in cabinet 4 for loops 1 through 6, plugs P115 and P119 in cabinet 5 for loops 7 through 10, and plugs P112, P115, and P119 in cabinet 6 for loops 11 through 16. The signals continue through the associated cables W112, W115, and W119 and terminals 1 and 2 of terminal boards TB112, TB115, and TB119, in cabinet 4, through cables W115 and W119 and terminals 1 and 2 of terminal boards TB115 and TB119, in cabinet 5, and cables W112, W115, and W119 and terminals 1 and 2 of terminal boards TB113, TB115, and TB119 in cabinet 6. Signals intended for loops 1 through 6 leave cabinet 4 at terminals 1 through 6 respectively of terminal board TB101, passing through terminals A through F of connector J2 and plug P152 of intercabinet cable assembly W151 No. 4, and terminals A through F of plug P151 and J4 in cabinet 5. The signals are routed through cabinet 5 by way of terminals 1 through 6 of terminal boards TB103 and TB101, continuing through terminals A through F of connector J2, plug P152 of intercabinet cable assembly W151 No. 6, plug P151, to terminals A through F of connector J4 in cabinet 6. In cabinet 6, the signals continue through terminals 1 through 6 of terminal board TB105 and are connected to telegraph loops 1 through 6 at terminals 1, 3, 5, and 9 of terminal board TB101 and terminal 1 of terminal board TB102. Ground is supplied for loops 1 through 6 at terminals 2, 4, 6, 8, and 10 of terminal board TB101 and terminal 2 of terminal board TB102. Signals for loops 7 through 10 leave cabinet 5 at terminals 7 through 10 of terminal board TB101 and are routed to cabinet 6 through terminals G through K of connector J2, plugs P151 and P152 of intercabinet cable assembly W151 No. 6, to terminals G through K of connector J2. In cabinet 6, the signals continue through terminals 7 through 10 of terminal board TB105, and are connected to loops 7 through 10 at terminals 3, 5, 7, and 9 of terminal

board TB102 in cabinet 6. Ground is supplied for these loops at terminals 4, 6, 8, and 10 on terminal board TB102. Signals for loops 11 through 16 in cabinet 6 connect to terminals 1, 3, 5, 7, and 9 of terminal board TB103 and terminal 1 of terminal board TB104. Ground for these loops is supplied at terminals 2, 4, 6, 8, and 10 of terminal board TB103 and terminal 2 of terminal board TB104.

## 205. Receiving Terminal, 3-Kc Lines, Schematic Diagram Analysis

Figure 253 shows the receiving terminal arranged for operation over 3-kc interconnecting line facilities. Demultiplexers 1, 2, and 3 are removed from cabinet 3 and installed at the radio receiver site. Audiofrequency amplifiers 1 and 2 replace demultiplexers 1 and 2. Dummy circuit panels Nos. 1 and 2 replace audiofrequency amplifiers Nos. 1 and 2 and DUMMY CIRCUIT PANEL No. 3 replaces demultiplexer 3.

*a. Voice-frequency Circuits.* Signals from four 3-kc lines enter the receiving terminal at cabinet 3. Line 1 connects to terminals 9 and 10 of terminal board TB101. Lines 2, 3, and 4 connect to terminal board TB102 at terminals 1 and 2, 3 and 4, and 5 and 6, respectively. Four additional 3-kc lines (lines No. 5–8) may be connected to terminal boards TB102 and TB103 if additional equipment is added to the basic AN/FGC–29 terminal as described in paragraph 59. In figure 253, the telegraph signals are shown applied to the terminal over lines 1 and 2. Other routines are possible as described in paragraphs 55 and 56 and shown on the space and frequency diversity routing diagrams for the receiving terminal (figs. 38 and 40). Telegraph signals from terminals 9 and 10 of terminal board TB101 are applied through terminals 1 and 2, to terminals 24 and 25 of terminal board TB1 of Transformer Assembly TF–206/FG No. 1. Terminals 24 and 25 are shown connected to 600-ohm terminals 23 and 26 for routing signals to the 600-ohm taps on the primary winding at terminals 6 and 11 of transformer T1. Other impedance matching connections are possible as described in paragraph 53. Similarly, diversity telegraph signals are applied to transformer T2 through terminals 1 and 2 of terminal board TB102 and terminals 3 and 4 of terminal board TB1 with terminals 32 and 33 strapped to 600-ohm connections 31 and 34 of terminal board TB1 which connect to primary terminals 6 and 11. Signals for transformer T3 from line No. 3 are applied through terminals 3 and 4 of terminal boards TB102 and terminals 5 and 6 of terminal board TB1 on Transformer Assembly TF–206/FG No. 1 with terminals 40 and 41 strapped to terminals 39 and 42 which connect to the 600-ohm terminals 6 and 11 of the transformer primary. Signals from line No. 4 are applied to transformer T4 through terminals 5 and 6 of terminal board TB102 and terminals 7 and 8 of terminal board TB1, with terminals 48 and 49 strapped to terminals 47 and 50, which connect in turn to the 600-ohm primary terminals 6 and 11 of the transformer. Signals from transformer T1 leave Transformer Assembly TF–206/FG No. 1 at terminals 9 and 10 of terminal board TB1, from transformer T2 at terminals 11 and 12, from transformer T3 at terminals 13 and 14, and from transformer T4 at terminals 15 and 16. Simplex connections to the midpoints of the primary windings of transformers T1 through T4 for dc signaling equipment are available for lines No. 1 through 4 on terminal board TB1 of Transformer Assembly TF–206/FG No. 1. Connections to simplex 1 through simplex 4 are made at terminals 1 through 4 of terminal board TB101 by way of terminals 17 through 20 of terminal board TB1. The signal path for signals from transformer T1 is cut through DUMMY CIRCUIT PANEL NO. 1 from terminals 1 and 2 of terminal board TB111 to terminals 5 and 6 of the same terminal board, passing through cable W111, terminals A and B of plug P111 and connector J2, and terminals E and F of the same plug and connector. The signals continue through terminals 1 and 2 of terminal board TB116 and cable W116 to terminals A and B of plug P116 and connector J26 in audiofrequency amplifier No. 1. Ground is brought into audiofrequency amplifier No. 1 from terminal 9 of terminal board TB116 to terminal J of connector J26 through cable W116 and plug P116. Diversity telegraph signals from transformer T2 proceed to audiofrequency amplifier No. 2 directly through terminals 3 and 4 of terminal board TB116, cable W116, and terminals C and D of plug P116 and connector J26. The telephone or facsimile signals from transformer T3 are cut through DUMMY CIRCUIT PANEL No. 1 from terminals 3 and 4 of terminal board TB111 to terminals 7 and 8 of the same terminal board, passing through cable W111, terminals C and D of plug P111 and connector J2, and ter-

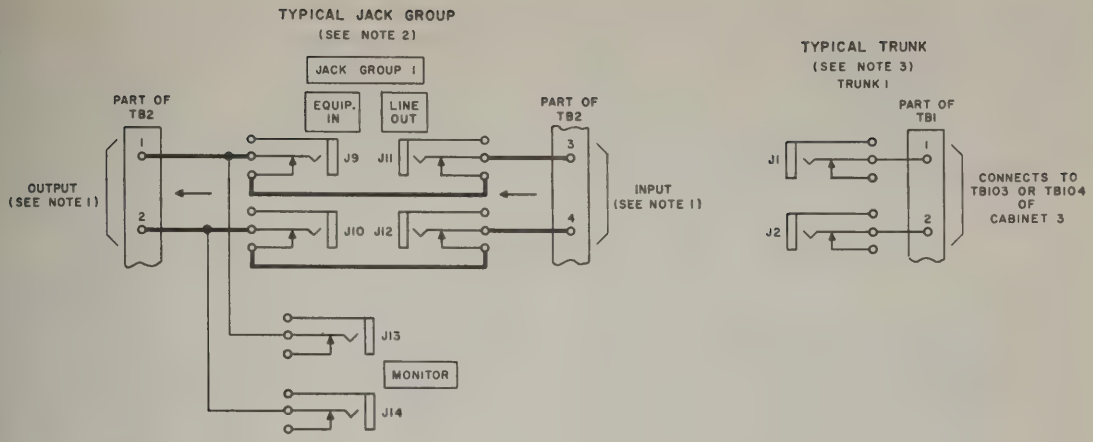
minals G and H of the same plug and connector. The signals continue through terminals 1 and 2 of terminal board TB117, and cable W117 to terminals A and B of plug P117 and connector J26 on audiofrequency amplifier No. 2. Signals from transformer T4 proceed to audiofrequency amplifier 2 directly through terminals 3 and 4 of terminal board TB117, cable W117, and terminals C and D of plug P117 and connector J26. Ground is brought into audiofrequency amplifier 2 from terminal 9 of terminal board TB117 to terminal J of connector J26 through cable W117 and plug P117. Audiofrequency amplifiers 1 and 2 provide the equalization and amplification necessary to compensate for signal losses incurred in lines 1 through 4. Telegraph signals for JACK GROUP 1 of the 3KC RECEIVE BAND TEST PANEL leave audiofrequency amplifier No. 1 at terminals E and F, and for JACK GROUP 2 from terminals G and H of connector J26 and plug P116. These signals pass through cable W116, terminal board TB116 at terminals 5 and 6 and terminals 7 and 8, arriving at terminal board TB2, terminals 3 and 4, and terminals 7 and 8, respectively, of the 3KC RECEIVE BAND TEST PANEL. Telephone or facsimile signals for JACK GROUP 3 leave audiofrequency amplifier No. 2 at terminals E and F and for JACK GROUP 4 from terminals G and H of connector J26 and plug P117. These signals pass through cable W117, terminal board TB117 at terminals 5 and 6, and terminals 7 and 8, arriving at terminal board TB3 at terminals 3 and 4 and terminals 7 and 8, respectively, on the 3KC RECEIVE BAND TEST PANEL. Telegraph signals from JACK GROUP 1 for the A path, and JACK GROUP 2 for the B path of the telegraph receiver group leave at terminals 1 and 2 and terminals 5 and 6, respectively, of terminal board TB2 and pass through terminals 5 and 6 and terminals 7 and 8, respectively, of terminal board TB107 (strapped to terminals 1 and 2 and terminals 3 and 4, respectively, of the same terminal board) to terminals A and B and terminals C and D, respectively, of connector J2. The signals continue through plug P152, cable W151, and plug P151 of intercabinet cable assembly No. 2 to terminals A and B and terminals C and D of connector J4 in cabinet 4 of the telegraph receiver group. Telephone or facsimile signals leave JACK GROUP 3 and JACK GROUP 4 at terminals 1 and 2 and terminals 5 and 6, respectively, of terminal board TB3 and pass to terminals 9 and 10 of terminal board TB107 and terminals 1 and 2 of terminal board TB108. Here connection is made to external telephone or facsimile receiving equipment. The output windings of transformers T1 through T4 on Transformer Assembly TF–206/FG No. 2 (for lines 5–8) are brought through JACK GROUP 5 through JACK GROUP 8, respectively, of the 3KC RECEIVE BAND TEST PANEL to terminals 3 through 10 of terminal board TB108. These facilities are used to provide additional 3-kc facilities between the radio receiver site and the communication center when additional equipment is added to the basic AN/FGC–29 terminal as described in paragraph 59. The circuits from transformers T1 and T3 first pass through DUMMY CIRCUIT PANEL 2 and then through dummy circuit panels No. 3 and 4, respectively, to JACK GROUP 5 and JACK GROUP 7. The circuits from transformers T2 and T4 pass through dummy circuit panels No. 3 and 4, respectively, to JACK GROUP 6 and JACK GROUP 8. Four additional simplex connections are available from the midpoints of transformer T1 through T4 of Transformer Assembly TF–206/FG No. 2 at terminals 5 through 8, respectively, on terminal board TB101.

*b. Telegraph Receiver Group.* The schematic diagram analysis of the telegraph receiver group arranged for operation with 3-kc interconnecting line facilities is identical with the analysis for operation with 6-kc line facilities (par. 204).

## 206. Theory of 3KC RECEIVE BAND TEST PANEL

(fig. 140)

The 3KC RECEIVE BAND TEST PANEL provides a central position in the receiving terminal for monitoring and patching the received vf circuits. The panel contains eight jack groups (JACK GROUP 1 through JACK GROUP 8) to permit monitoring or patching of up to eight 3-kc signal bands (par. 205). Each jack group contains a LINE OUT, an EQUIP IN, and a MONITOR jack pair. The LINE OUT jacks allow for measurement of the incoming signal level and permit the signals to be patched to the EQUIP IN jacks of a different vf circuit. The EQUIP IN jacks allow the introduction of test signals to receiving telegraph, telephone, or facsimile equipment and permit the equipment to be patched to the LINE OUT jacks of a different vf circuit. The MONITOR jacks are connected across the




NOTES:

1. FOR INPUT AND OUTPUT CONNECTIONS REFER TO SCHEMATIC DIAGRAM OF RECEIVING TERMINAL.

2. REFERENCE SYMBOLS FOR ALL JACK GROUPS APPEAR IN TABLE BELOW.

| JACK GROUP | JACK LABEL | JACK REF SYMBOL | CONNECTS TO | |
|---|---|---|---|---|
| | | | TERMINAL BOARD | TERMINAL NO. |
| 1 | EQUIP. IN | J9 | TB2 | 1 |
| | | J10 | TB2 | 2 |
| | LINE OUT | J11 | TB2 | 3 |
| | | J12 | TB2 | 4 |
| | MONITOR | J13 | — | — |
| | | J14 | — | — |
| 2 | EQUIP. IN | J15 | TB2 | 5 |
| | | J16 | TB2 | 6 |
| | LINE OUT | J17 | TB2 | 7 |
| | | J18 | TB2 | 8 |
| | MONITOR | J19 | — | — |
| | | J20 | — | — |
| 3 | EQUIP. IN | J21 | TB3 | 1 |
| | | J22 | TB3 | 2 |
| | LINE OUT | J23 | TB3 | 3 |
| | | J24 | TB3 | 4 |
| | MONITOR | J25 | — | — |
| | | J26 | — | — |
| 4 | EQUIP. IN | J27 | TB3 | 5 |
| | | J28 | TB3 | 6 |
| | LINE OUT | J29 | TB3 | 7 |
| | | J30 | TB3 | 8 |
| | MONITOR | J31 | — | — |
| | | J32 | — | — |
| 5 | EQUIP. IN | J33 | TB4 | 1 |
| | | J34 | TB4 | 2 |
| | LINE OUT | J35 | TB4 | 3 |
| | | J36 | TB4 | 4 |
| | MONITOR | J37 | — | — |
| | | J38 | — | — |
| 6 | EQUIP. IN | J39 | TB4 | 5 |
| | | J40 | TB4 | 6 |
| | LINE OUT | J41 | TB4 | 7 |
| | | J42 | TB4 | 8 |
| | MONITOR | J43 | — | — |
| | | J44 | — | — |
| 7 | EQUIP. IN | J45 | TB5 | 1 |
| | | J46 | TB5 | 2 |
| | LINE OUT | J47 | TB5 | 3 |
| | | J48 | TB5 | 4 |
| | MONITOR | J49 | — | — |
| | | J50 | — | — |
| 8 | EQUIP. IN | J51 | TB5 | 5 |
| | | J52 | TB5 | 6 |
| | LINE OUT | J53 | TB5 | 7 |
| | | J54 | TB5 | 8 |
| | MONITOR | J55 | — | — |
| | | J56 | — | — |

3. REFERENCE SYMBOLS FOR ALL TRUNKS APPEAR IN TABLE BELOW.

| TRUNK | JACK REF SYMBOL | CONNECTS TO | |
|---|---|---|---|
| | | TERMINAL BOARD | TERMINAL NO. |
| 1 | J1 | TB1 | 1 |
| | J2 | TB1 | 2 |
| 2 | J3 | TB1 | 3 |
| | J4 | TB1 | 4 |
| 3 | J5 | TB1 | 5 |
| | J6 | TB1 | 6 |
| 4 | J7 | TB1 | 7 |
| | J8 | TB1 | 8 |
| 5 | J57 | TB6 | 1 |
| | J58 | TB6 | 2 |
| 6 | J59 | TB6 | 3 |
| | J60 | TB6 | 4 |
| 7 | J61 | TB6 | 5 |
| | J62 | TB6 | 6 |
| 8 | J63 | TB6 | 7 |
| | J64 | TB6 | 8 |

TM2245-365

*Figure 140. 3KC RECEIVE BAND TEST PANEL, schematic diagram.*

signal path immediately following the EQUIP IN jacks and permit monitoring of the received vf signal. The 3KC RECEIVE BAND TEST PANEL also contains eight trunk jack pairs (TRUNK 1–TRUNK 8) which connect to terminal boards TB103 and TB104 in cabinet 3 of the receiving terminal to pick up general purpose trunk circuits brought to these terminal boards for patching, monitoring, or testing purposes. A typical jack group and typical trunk jack pair are shown in the schematic diagram of the 3KC RECEIVE BAND TEST PANEL (fig. 140) with tables listing the reference symbols and terminal board connections.

## Section XII. THEORY OF REMOTE CONTROL CIRCUITS

### 207. General

Switching of the transmitters in the transmitting terminal, or the combiners in the receiving terminal, for either two-channel or four-channel diversity operation may be accomplished either manually at the terminal, or electrically from a remote control station. The theory of remote switching circuits for the transmitters is discussed in paragraph 146*e*, and for the combiner in paragraph 190*e*. The external connections required for the remote control circuits to the transmitting terminal are discussed in paragraph 52*a*(5) and for the receiving terminal in paragraph 52*c*(5). The theory of the remote control circuits for the transmitting terminal is discussed in paragraph 208 and for the receiving terminal in paragraph 209.

### 208. Transmitting Terminal, Theory of Remote Control Circuits

(fig. 141)

Operating voltage at —130 volts to ground for the remote control switches at the remote control station associated with TRANSMITTER CHANNELS 1 and 2 through 15 and 16 is applied at terminal G or terminal H of connector J16 in each transmitter depending on the position of DIVERSITY switch S5 (par. 146). In the 2-CHANNEL LOOPS 1 and 2 position of this switch, connection is established through terminal G and in the 4-CHANNEL LOOP 1 ONLY position, through terminal H of connector J16 in TRANSMITTER CHANNELS 1 and 2. In the remaining transmitters, the connection is established through the corresponding terminals when switch S5 in each transmitter is in the comparable position. When the remote control switches are operated the control voltages from the transmitters in cabinet 2 are applied to terminal G or H of plugs P113 through P120, associated cables W113 through W120, and terminals 7 or 8, respectively, of terminal boards TB113 through TB120 to the appropriate terminal of terminal pairs 1–2 through 9–10, respectively, on terminal board TB105 and terminal pairs 1–2 through 5–6, respectively, of terminal board TB106. From here the control voltages pass to the remote control station and the remote control switches associated with TRANSMITTER CHANNELS 1 and 2 through 15 and 16.

### 209. Receiving Terminal, Theory of Remote Control Circuits

(fig. 142)

Operating voltage at —130 volts to ground for the remote control switches associated with COMBINER CHANNELS 1 and 2 through 15 and 16 is applied at either terminal N or terminal P of connector J10 in each combiner depending on the position of DIVERSITY switch S5. In the 2-CHANNEL LOOPS 1 and 2 position, connection is established through terminal N and in the 4-CHANNEL LOOP 1 ONLY position, through terminal P of connector J10 in COMBINER CHANNELS 1 and 2. In the remaining combiners, connection is established through the the corresponding terminals when switch S5 in each combiner is in the comparable position. When the associated remote control switches are operated, the control voltages from the combiners in cabinet 4 are applied through terminal N or P of plugs P112, P115, and P119; terminal 13 or 14, respectively, of terminal boards TB112, TB115, and TB119, to the appropriate terminal of terminal pairs 1–2, 3–4, and 5–6, respectively, of terminal board TB104. From here the control voltages pass to the remote control station and the remote control switches associated with COMBINER CHANNELS 1 and 2, 3 and 4, and 5 and 6. When the associated remote control switches are operated, the control voltages from the combiners in cabinet 5 are applied through terminals N or P of plugs P115 and W119, terminals 13 and 14, respectively, of terminal boards TB115 or TB119 to the appropriate terminal of

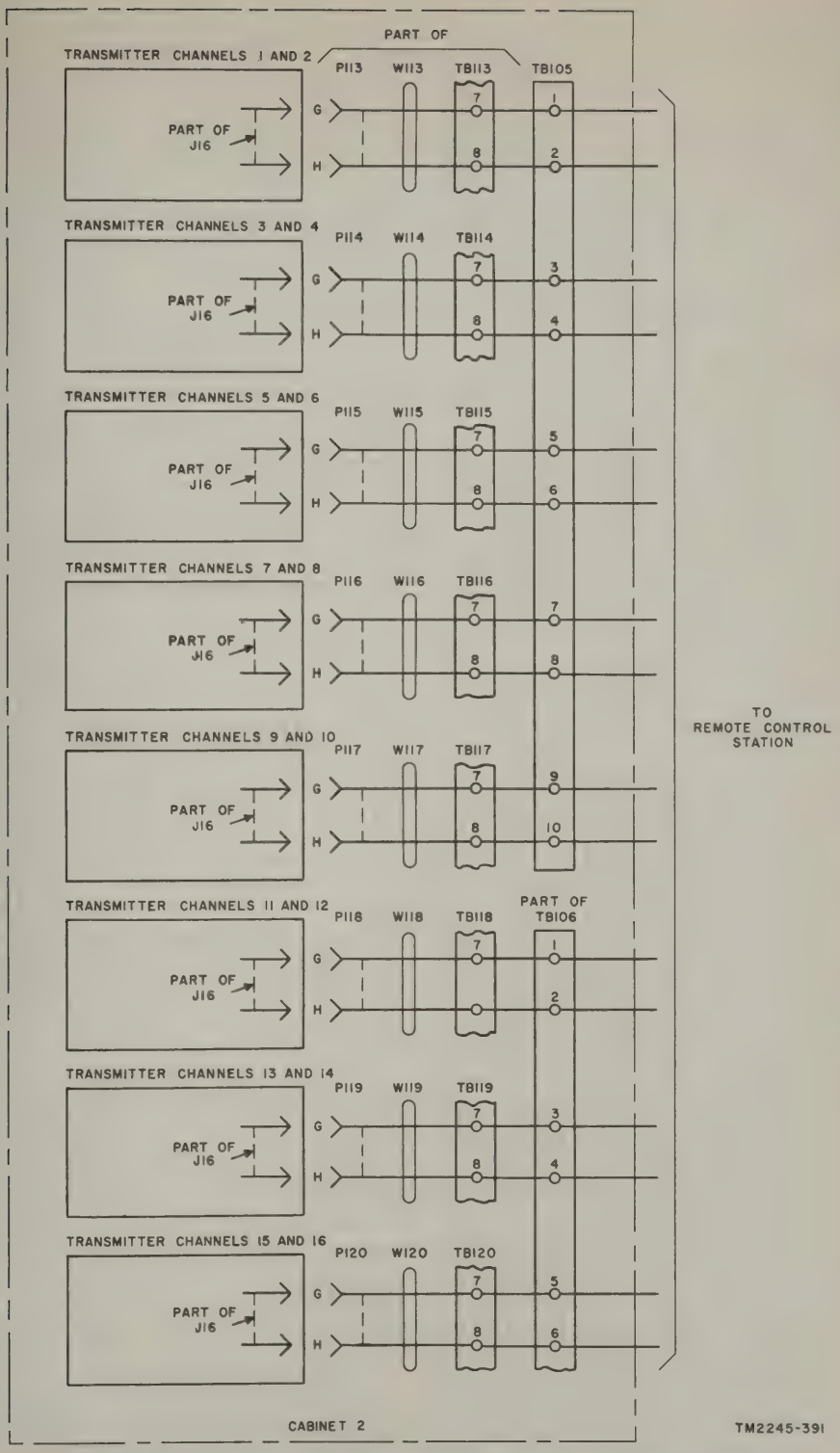



*Figure 141. Transmitting terminal, remote control switching, schematic diagram.*

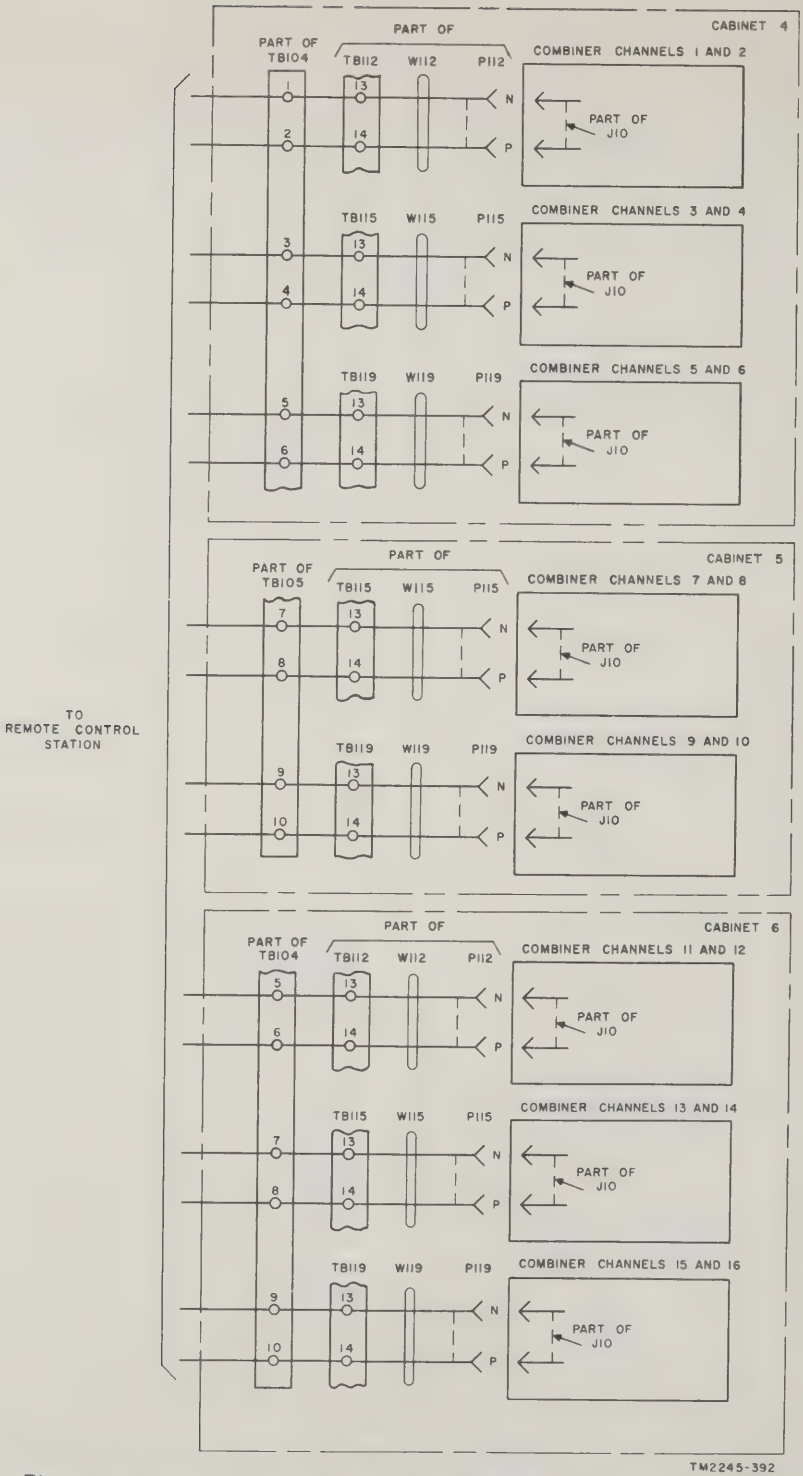



*Figure 142. Receiving terminal, remote control switching, schematic diagram.*

terminal pairs 7–8 and 9–10, respectively, on terminal board TB105. From here the control voltages pass to the remote control station and the remote control switches associated with COMBINER CHANNELS 7 and 8, 9 and 10, and 11 and 12. When the associated remote control switches are operated, the control voltages from the combiners in cabinet 6 are applied through terminal N of P of plugs P112, P115, and P119; associated cables W112, W115, and W119, and terminal 13 or 14, respectively, of terminal boards TB112, TB115, and TB119 to the appropriate terminal of terminal pairs 5–6, 7–8, and 9–10, respectively, on terminal board TB104. From here the control voltages pass to the remote control station and the remote control switches associated with COMBINER CHANNELS 11 and 12, 13 and 14, and 15 and 16.

## Section XIII. THEORY OF AC POWER DISTRIBUTION

### 210 General

The AN/FGC–29 terminal requires a power source, or sources, totaling 4,500 watts in capacity and delivering either 115 volts ac or 230 volts ac ±10 percent at 50 or 60 cps. Three power entrances are provided, one in the transmitting terminal and two in the receiving terminal, each requiring approximately 1,500 watts. The transmitting terminal power circuits are separate and independent of the receiving terminal power circuits. Transformers and voltage regulators provided at each power entrance deliver unregulated 115 and 230 volts ac and regulated 230 volts ac for operation of various terminal components. Connections to external power and signal ground, and connections to cabinet and intercabinet power wiring are made in power terminal boxes in each cabinet.

### 211. Transmitting Terminal Distribution

(fig. 260)

Figure 260 is a schematic diagram showing the ac power distribution circuits in the transmitting terminal, cabinets 1 and 2.

*a. Cabinet 1.* Power from a primary power source at 107 to 122 or 210 to 250 volts ac, 50 or 60 cps, is applied to terminals 1 and 2 of terminal board TB131 in the power terminal box of cabinet 1. The signal ground is applied to terminals 3 and 4 of terminal board TB131 and is connected to cabinet 1 chassis ground in the power terminal box. Primary power from the terminal box is applied to terminals 1 and 2 of ON-OFF power switch S1 in the main power unit. Terminal 4 of switch S1 connects one side of the primary power, (through fuse F5 bridged by blown fuse indicator I5) to terminal 1 on autotransformer T1 and to the common side of the ac distribution circuit, by way of terminal 3 on terminal board TB132 in the power terminal box. Terminal 3 of switch S1 connects the other side of the primary power to the one of terminals 2 through 7 on autotransformer T1 which corresponds to the voltage of the primary power source. The 115-volt ac output from terminal 3 on autotransformer T1 passes through fuse F4 (bridged by blown fuse indicator I4) to the 115-volt ac power distribution circuits by way of terminal 2 on terminal board TB132 in the power terminal box. The 230-volt ac output from terminal 6 on autotransformer T1 passes through fuse F3, bridged by blown fuse indicator I3, to the 230-volt ac power distribution circuits by way of terminal 1 on terminal board TB132 in the power terminal box. The 115-volt ac power distribution circuit, together with the common ac distribution circuit, furnishes power to terminals 1 and 2, respectively, of terminal boards TB121, TB122, TB123, TB126, TB127, and TB130, and to connector J1 in the power panel through fuses F2 and F1. Terminal boards TB121 and TB122 supply power through cables W121 and W122, and plugs P121 and P122, respectively, to connectors J25 of the audiofrequency amplifiers. Connector J6 of the TRANSMITTER METER PANEL receives power from terminal board TB123 through cable W123 and plug P123. Connectors J24 of multiplexers No. 1 and 2 receive power from terminal boards TB126 and TB127, respectively, by way of cables W126 and W127 and plugs P126 and P127. Power is applied to connector J6 of the LOOP BATTERY PANEL from terminal board TB130 through cable W130 and plug P130. Connector J6 supplies power to connector J2 through fuses F19 and F20 (bridged by BLOWN FUSE INDICATORS I 19 and I20) and to connector J3 by way of fuses F21 and F22 (bridged by BLOWN FUSE INDICATORS I21 and I22). RECTIFIER A loop battery supply accepts power from connectors J2 through plug P1 and cable W1 to terminals 3 and 4 on terminal board TB1. RECTIFIER B loop battery accepts power from connectors J3 through plug P1 and cable W1

to terminals 3 and 4 on terminal board TB1. BLOWER MOTOR BLOWN FUSE INDICATORS I 1 and I2 are located on the front cover panel of cabinet 1. Indicator I 1 is bridged across fuse F1 in the power panel through resistor R1, cable W136, and terminals A and B of plug P136 and connector J136. Indicator I2 is similarly bridged across fuse F2 through resistor R2, cable W136, and terminals C and D of plug P136 and connector J136. The blower motor receives power through cable W1 and plug P1 from connector J1 of the power panel. The 230-volt ac, 115-volt ac, and common ac power distribution circuits leave cabinet 1 from terminals 1, 2, and 3, respectively, on terminal board TB132 in the power terminal box and pass through intercabinet power wiring to the power distribution circuits in cabinet 2 by way of terminals 1, 2, and 3, respectively, on terminal board TB132 of the power terminal box in cabinet 2. Signal ground from terminal 3 on terminal board TB131 in cabinet 1 is brought through intercabinet wiring into cabinet 2 at terminals 2 and 1 on terminal board TB131 in the power terminal box and is applied to the cabinet 2 chassis ground.

*b. Cabinet 2.* The 115-volt ac power distribution circuit in cabinet 2 together with the common distribution circuit furnishes power to terminals 7 and 8 on terminal board TB1 of the AC POWER SWITCHING PANEL and to connector J1 through fuses F1 and F2 on the power panel. Connections from the power panel to the blower motor and BLOWER MOTOR BLOWN FUSE INDICATORS I 1 and I2 are identical with the arrangement in cabinet 1 (*a* above). Power from terminals 7 and 8 on terminal board TB1 on the AC POWER SWITCHING PANEL is applied through fuses F3 and F4, bridged by BLOWN FUSE INDICATORS I3 and I4, to the 115-volt utility outlets. The 230-volt ac power distribution circuit together with the common circuit applies power to voltage regulator switch S1 and output voltage switch S2. Switch S1, in the ON position, feeds 230-volt ac to input terminals 1 and 2 on terminal board TB1 of the voltage regulator (par. 214) through fuses F1 and F2, bridged by BLOWN FUSE INDICATORS I 1 and I2, and terminals 3 and 2 on terminal board TB1. The chassis ground connection of the voltage regulator appearing on terminal 5 is connected to the cabinet signal ground. The regulated output of the voltage regulator on terminal 3 of terminal board TB1 passes through terminal 1 on terminal board TB1 of the AC POWER SWITCHING PANEL to switch S2. When in the REG position, switch S2 applies regulated 230 volts to terminals 4 and 5 on terminal board TB1 and to OUTPUT VOLTAGE meter M1. When the voltage regulator fails, switch S2 is placed in the UNREG position so that the unregulated 230 volts ac on terminals 6 and 8 of terminal board TB1 is applied to terminals 4 and 5 and meter M1 to permit emergency operation of the transmitter group. The 230-volt ac regulated power from terminals 4 and 5 of terminal board TB1 is applied by way of terminals 1 and 2 of terminal board TB133 in the power terminal box to terminals 1 and 2 of terminal boards TB121 through TB130 and then through cables W121 through W130, respectively, to plugs P121 through P130. Plug P121 applies power to connector J17 of the LEVEL CONTROL & PLATE SUPPLY. Plug P122 applies power to connector J18 of the SUB-GROUP MODULATOR. Plugs P123 through P130 apply power to connectors J15 in TRANSMITTERS CHANNELS 1 and 2 through 15 and 16.

## 212. Receiving Terminal Distribution
(fig. 261)

Figure 261 is a schematic diagram showing the ac power distribution circuits in the receiving terminal, cabinets 3 through 6. Primary power is applied to both cabinets 3 and 5.

*a. Cabinet 3.* Primary power at 107 to 122 or 210 to 250 volts ac, 50 or 60 cps, is applied to terminals 1 and 2 of terminal board TB131 in the power terminal box. The signal ground for the receiving terminal is applied to terminals 3 and 4 on terminal board TB131 and is connected to cabinet 3 chassis ground. The ac power distribution circuits in cabinet 3 for the power terminal box, main power unit, power panel, blower motor, cover panel, LOOP BATTERY PANEL and loop battery supplies are identical to the ac power distribution circuits in cabinet 1 (par. 211*a*) for these units. The 115-volt ac distribution circuit, together with the common distribution circuit, furnishes power to plugs P121, P122, P123, P126, P127, and P130 by wiring identical to that in cabinet 1. Two additional plugs P128 and P129 are supplied with 115-volt ac power through terminals 1 and 2 on terminal boards TB128 and TB129, respectively, by way of cables W128 and W129. Plugs P121 and P122 connect power to connectors J25 for audiofrequency amplifiers No.

1 and 2, respectively. Plug P123 supplies power to the DIVERSITY ALIGNMENT PANEL through connector J13. Plugs P126, P127, and P128 connect power to connectors J24 of demultiplexers No. 1, 2, and 3, respectively. When DUMMY CIRCUIT PANEL No. 4 is replaced by demultiplexer No. 4, power is supplied from plug P129. The 230-volt ac, 115-volt ac, and the common ac power distribution circuits leave cabinet 3 from terminals 1, 2, and 3, respectively, on terminal board TB132 in the power terminal box and pass through intercabinet power wiring to the ac power distribution circuits in cabinet 4 by way of terminals 2, 3, and 4, respectively, on terminal board TB132 of the power terminal box in cabinet 4. Signal ground from terminal 3 on terminal board TB131 in cabinet 3 is brought through intercabinet wiring into cabinet 4 at terminals 2 and 1 on terminal board TB131 in the power terminal box and is applied to the cabinet 4 chassis ground.

*b. Cabinet 4.* Power distribution in cabinet 4 by way of terminals 2, 3, and 4 of terminal board TB132 of the power terminal box to the power panel, cover panel, blower motor, AC POWER SWITCHING PANEL, and the voltage regulator is identical with the distribution in cabinet 2 (par. 211*b*) for these units. The 230-volt ac regulated power from terminals 4 and 5 on terminal board TB1 of the AC POWER SWITCHING PANEL furnishes power to plugs P121, P123, P124, P126, P128, and P130 through terminals 1 and 2 on terminal boards TB121, TB123, TB124, TB126, TB128, and TB130, respectively, by way of cables W121, W123, W124, W126, W128, and W130. These plugs apply power to connectors J15 in receiver channels 1 through 6, respectively. The 230-volt ac grounded power from cabinet 5 enters cabinet 4 through terminal 1 on terminal board TB132 of the power terminal box and is distributed to terminal 2 on terminal boards TB122, TB125, and TB129. Signal ground is applied to terminal 1 on each of these terminal boards. The 230-volt ac between terminals 1 and 2 on terminal boards TB122, TB125, and TB129 passes through cables W122, W125, and W129, respectively, through polarized plugs P122, P125, and P129 to polarized connectors J9 on COMBINER CHANNELS 1 and 2 through channels 5 and 6, respectively. Regulated 230-volt ac from terminals 4 and 5 on terminal board TB1 of the AC POWER SWITCHING PANEL passes through terminals 2 and 1 on terminal board TB133 in the power terminal box of cabinet 4 and through intercabinet wiring to terminal 1 and 2 on terminal board TB133 of the power terminal box in cabinet 5. Signal ground from terminal 1 on terminal board TB131 of cabinet 4 power terminal box is brought through intercabinet wiring into cabinet 5 at terminals 3 and 4 on terminal board TB131 of the power terminal box and is applied to the cabinet 5 chassis ground.

*c. Cabinet 5.* Primary power at 107 to 122 or 210 to 250 volts ac is applied to terminals 1 and 2 of terminal board TB131 in the power terminal box and proceeds to the voltage regulator switch S1 in the main power unit. This unit is identical with the main power unit in cabinet 1 (par. 211*a*). The 230-volt ac power, 115-volt ac power, and the common connection from the main power unit are applied to the corresponding power distribution circuits in cabinet 5 by way of terminals 3, 4, and 5 on terminal board TB132 in the power terminal box. The 115-volt ac power is applied to the power panel and to terminals 1 and 2 of the step-up power transformer. The power panel, blower motor, and cover panel circuits are identical to the same circuits in cabinet 1 (par. 211*a*). Terminal 3 on the step-up power transformer is grounded and the 230 volts ac from terminal 4 is applied to terminal 2 on terminal boards TB123, TB125, and TB129. Ground is connected to terminal 1 on these terminal boards for power return. The 230-volt ac on terminal board TB123 is applied to connector J6 of the RECEIVER METER PANEL through cable W123 and plug P123. The 230-volt ac on terminal boards TB125 and TB129 is applied to polarized connectors J9 on combiners channels 7 and 8 and channels 9 and 10, respectively, through polarized plugs P125 and P129 and cables W125 and W129. The 230-volt ac regulated power on terminals 1 and 2 of terminal board TB133 of the power terminal box furnishes power to connector J24 of SUBGROUP DEMODULATOR A and connector J15 of receiver channels 7 and 8 through terminals 1 and 2 of terminal boards TB121, TB124, and TB126, respectively, by way of cables W121, W124, and W126, and plugs P121, P124, and P126, respectively. The 230-volt ac regulated power from cabinet 6 is applied by way of terminals 3 and 4 on terminal board TB133 in cabinet 5 power terminal box to connector J24 of SUBGROUP DEMODULATOR B and connector J15 of receiver channels 9 and 10, through terminals 1 and 2 of terminal

boards TB122, TB128, and TB130, respectively, cables W122, W128, and W130, and plugs P122, P128, and P130. The 230-volt ac, the 115-volt ac, and the common power distribution circuits leave cabinet 5 from terminals 3, 4, and 5, respectively, on terminal board TB132 in the power terminal box and pass through intercabinet power wiring to the ac power distribution circuits in cabinet 6 by way of terminals 2, 3, and 4 on terminal board TB132 in the power terminal box of cabinet 6. The 230-volt ac grounded power on terminals 1 and 2 of terminal board TB132 in cabinet 5 power terminal box passes through the intercabinet power wiring to terminal 1 on terminal board TB132 of the power terminal boxes in cabinets 4 and 6. Signal ground from terminal 3 on terminal board TB131 in cabinet 5 power terminal box is brought through intercabinet wiring into cabinet 6 at terminals 2 and 1 on terminal board TB131 in the power terminal box and is applied to the cabinet 6 chassis ground.

*d. Cabinet 6.* Power wiring to the power panel, cover panel, blower motor, AC POWER SWITCHING PANEL, and the voltage regulator is identical to the distribution in cabinet 4 (*b* above). The 230-volt ac regulated distribution from the AC POWER SWITCHING PANEL to receiver channels 11 through 16 is identical with the distribution in cabinet 4 for receiver channels 1 through 6, respectively (*b* above). The 230-volt ac regulated power from terminals 1 and 2 on terminal board TB133 in the power terminal box passes through the intercabinet power wiring to cabinet 5. The 230-volt ac grounded power distribution from terminal 1 on terminal board TB132 to COMBINER CHANNEL 11 and 12 through 15 and 16 is identical to the distribution in cabinet 4 for COMBINER CHANNEL 1 and 2 through 5 and 6, respectively (*b* above).

## 213. Theory of AC POWER SWITCHING PANEL

(figs. 260 and 261)

The ac power switching panels are located in cabinet 2 of the transmitting terminal and cabinets 4 and 6 of the receiving terminal. Each panel provides switching and metering facilities for an associated voltage regulator located in the same cabinet and also provides two 115-volt ac power outlets for general utility use. VOLTAGE REGULATOR switch S1 applies the 230 volts, 50 or 60 cps, from the primary power source to the voltage regulator. OUTPUT VOLTAGE switch S2 permits 230 volts from the voltage regulator, or unregulated power from the primary power source, to be applied to the output of the AC POWER SWITCHING PANEL. Continuous monitoring of the output voltage is provided by OUTPUT VOLTAGE meter M1. Ac power at 115 volts is available at the 115V UTILITY OUTLETS. The theory of the AC POWER SWITCHING PANEL is discussed in paragraph 211. The schematic diagram of the AC POWER SWITCHING PANEL is shown on the ac power distribution schematics for the transmitting terminal (fig. 260) and for the receiving terminal (fig. 261).

## 214. Voltage Regulator, Block Diagram Analysis

(fig. 143)

The voltage regulator accepts an input voltage ranging from 210 to 250 volts, 50 or 60 cps, and delivers an output of 230 volts ac, constant to within plus or minus .3 percent. Input power is applied through the ac winding of saturable reactor L1 to autotransformer T3 from which the regulator output is taken. Regulation is accomplished by automatically adjusting the voltage applied to the autotransformer to compensate for variation in supply voltage or regulator load. This is done by appropriately varying the series impedance of the ac winding of the saturable reactor to maintain a constant regulator output voltage. Adjustment of the ac winding impedance is accomplished by magnetic saturation of the reactor core under control of the current in a separate dc winding. Control diode V2 is the reference element of the regulator. It is operated in a temperature-limited condition so that its plate voltage varies greatly with small changes in its filament temperature. Control diode V2 regulates control amplifier V3 and consequently the current flowing in the dc winding of saturable reactor L1. B-plus voltage for tubes V2 and V3 is obtained from rectifier V1 which receives its power from control power transformer T1 connected across the output of the voltage regulator. Control power transformer T1 also supplies filament voltage for control diode V2 which is applied to the diode in series with compensating transformer T2. The value of the filament voltage is such as to bring the filament temperature of the control diode to the proper operating range. A typical sequence of operations is as follows: a reduction in the regulator load or an increase in

supply voltage causes a rise in regulator output voltage. Increased output voltage increases the filament temperature of control diode V2. As a result, the plate voltage of the diode decreases. This decrease applied to control amplifier V8 decreases the current flowing in the dc winding of saturable reactor L1 which causes an increase in the impedance of the ac winding. Increasing the impedance of the ac winding reduces the amount of supply voltage applied to autotransformer T3 which restores the regulator output voltage to normal. More accurate regulation is provided by a compensating circuit consisting of compensating transformer T2, load compensating resistor R1, and voltage compensating resistor R3. Load compensating resistor R1 improves the regulation of the regulator with respect to changes in regulator load. This resistor produces a small voltage which is proportional to the regulator load current. Voltage compensating resistor R3 improves the regulation of the regulator with respect to changes in supply voltage. This resistor produces a small voltage which is proportional to the regulator output voltage. The voltages from resistors R1 and R3 are applied to compensating transformer T2. Since transformer T2 is in series with the control diode filament circuit, the voltages from resistors R1 and R3 compensate the temperature of the diode filament to obtain improved regulation of output voltage. Resistors R1 and R3 are adjusted at time of manufacture for optimum compensation of the regulator output voltage. Suppression for harmonics of the power frequency is provided by the harmonic suppressors consisting of capacitor C2 and inductor L2 and capacitor C3 and inductor L3. Switch S5 selects the appropriate suppression for either 50- or 60-cps input.

## 215. Voltage Regulator, Schematic Diagram Analysis

(fig. 144)

The high potential side of the nominal 230-volt, 50- or 60-cps power source enters the regulator at terminal 1 on terminal board TB1 and connects directly to terminal 3 on autotransformer T3. The neutral side of the power source enters at terminal 2 of terminal board TB1 and is connected to terminal 1 on autotransformer T3 through the ac windings of saturable reactor L1. This circuit arrangement places the variable reactance windings of the saturable reactor, in series with the input of autotransformer T3, across the power source. Any variation in the impedance of the variable reactance windings alters the input voltage to autotransformer T3 thereby altering its output voltage. The particular pair of terminals 1–1, 2–2, or 3–3 to which connections are made on variable reactor L1 is determined at the time of manufacture and is selected for optimum performance of the voltage regulator. The impedance of the variable reactance windings of variable reactor L1 is automatically varied to compensate for variations in the voltage of the power source or regulator load. Output voltage from terminal 4 on autotransformer T3 is applied through load compensating resistor R1 to high potential output terminal 3 on terminal board TB1. Terminal 4 is the neutral output power terminal and is connected to the neutral side of the input power source. Inductor L2 in series with capacitor C2, bridged across terminals 2 and 3 on autotransformer T3, suppresses third harmonic distortion of the power frequency introduced by saturable reactor L1. Inductor L3 in series with capacitor C3, bridged across terminals 1 and 2 on autotransformer T3, similarly suppresses fifth harmonic distortion. Switch S1 selects the appropriate terminals of L2 and L3 to suppress harmonics of either 50 or 60 cycles and must be set in accordance with the frequency of the power source. All or part of the secondary windings of inductor L2 or L3 may be wired in series with the primaries of inductor L2 or L3 respectively at the time of manufacture to adjust the resonance of the tuned circuits to the correct frequency. Transformer T1 supplies power for operation of the voltage regulator control circuits. The regulator output voltage is applied to primary terminals 1 and 2 in series with voltage compensating resistor R3 and internally strapped terminals 3 and 4 of control diode V2B. Removal of control diode V2 from its socket opens the primary power circuit to transformer T1 to prevent excessive output voltage from the regulator. The voltage drop across resistor R3 in series with the voltage drop across load compensating resistor R1 is applied to primary terminals 1 and 2 of compensating transformer T2. Secondary terminals 8 and 9 of transformer T1 supply voltage for the filament of control diode V2A. This voltage is applied through the secondary winding, terminals 3 and 4, of transformer T2 and a resistive network, consisting of resistors R16 through R20, to the filament of control diode V2A. VOLTS ADJ resistor R16, shunted by resistor R20, permits adjustment

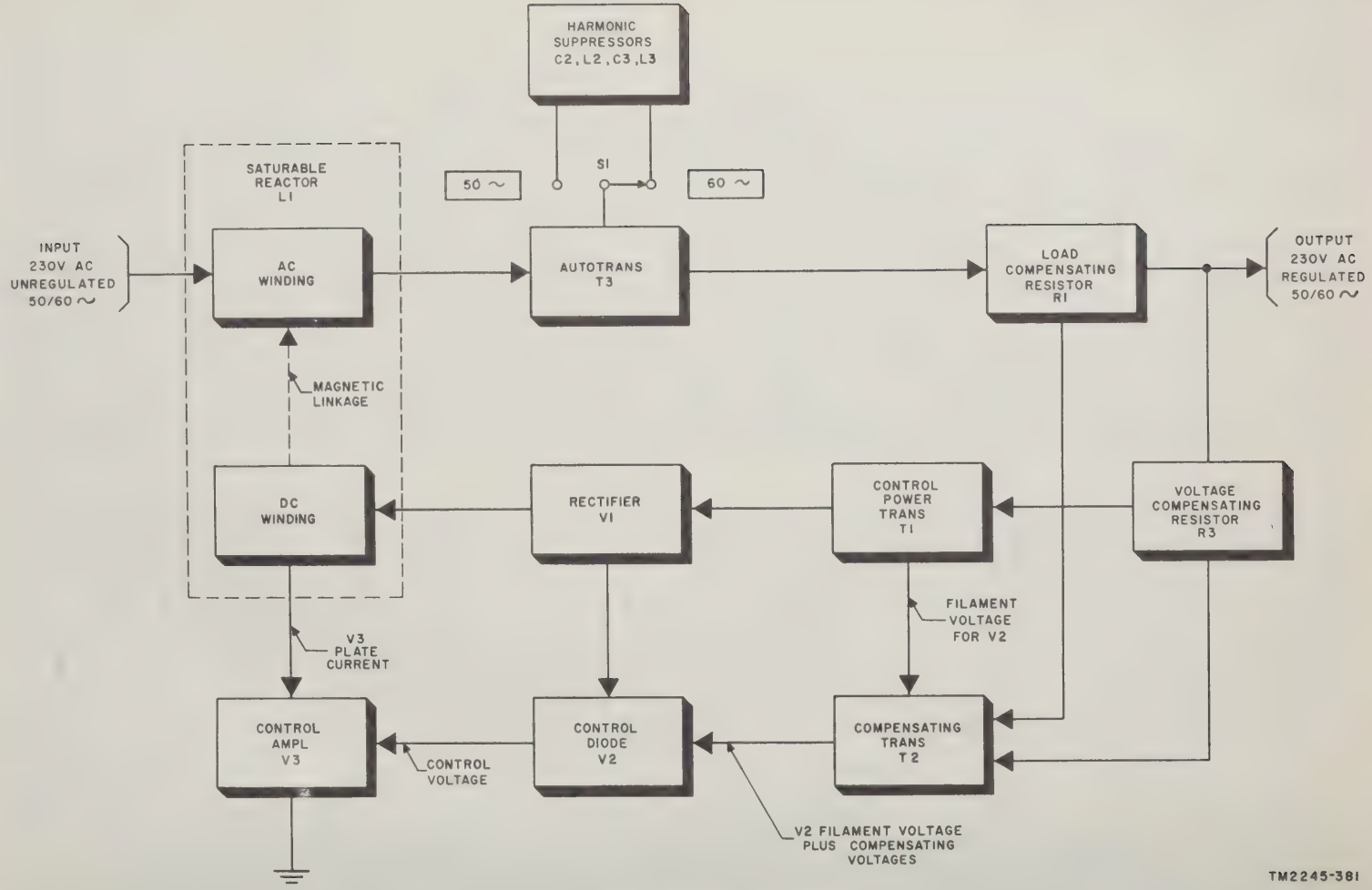
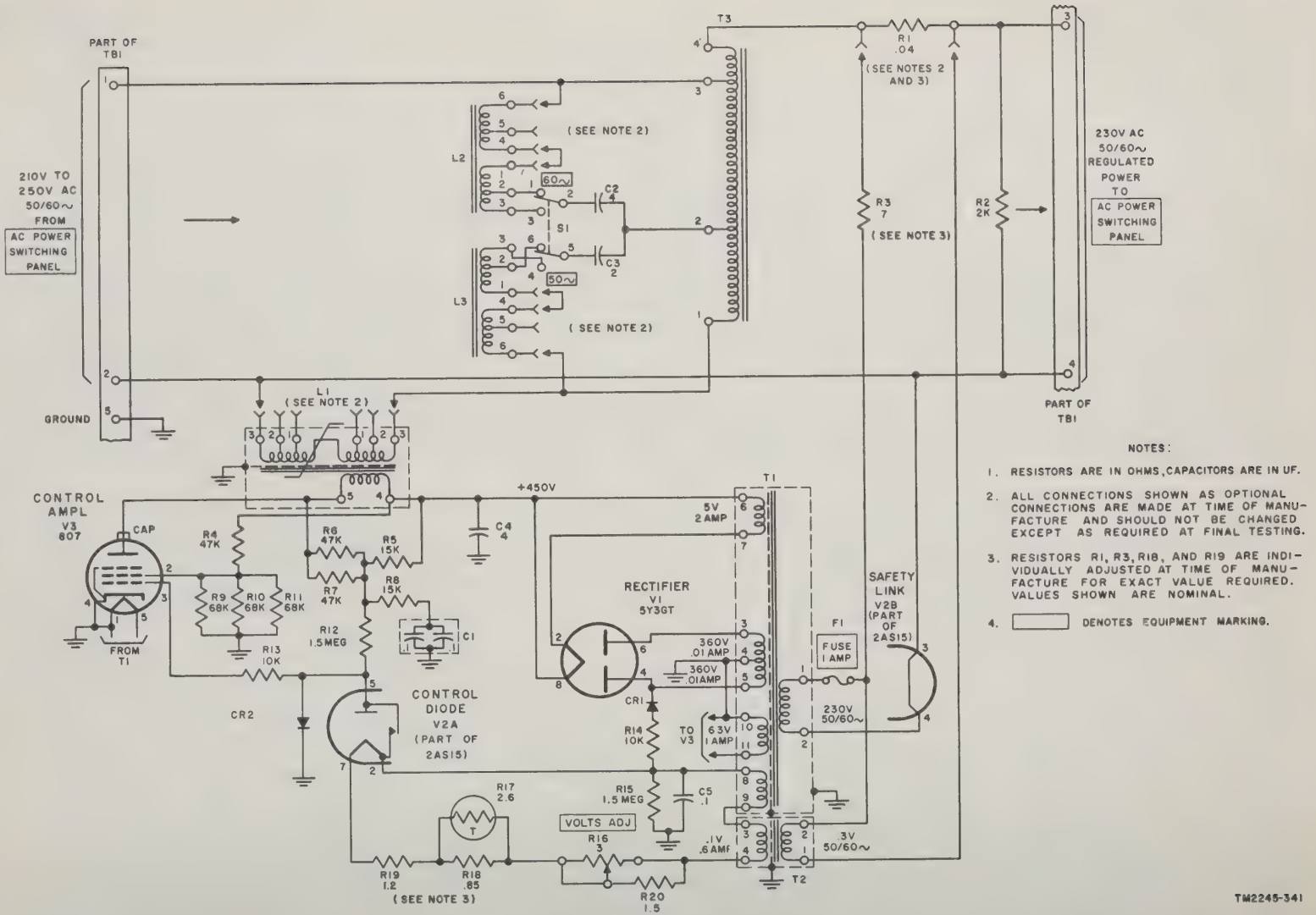



*Figure 143. Voltage regulator, block diagram.*

of the filament current to set the proper operating temperature of the filament for the desired regulator output voltage. Resistor R19 is adjusted at the time of manufacture so that the desired regulator output voltage falls within the range of VOLTS ADJ resistor R16. A negative temperature coefficient resistor, R17, in parallel with resistor R18 compensates the effect of ambient temperature changes on the regulator output voltage. Resistor R18 is adjusted at the time of manufacture for optimum temperature compensation. Filament voltage of 5 volts ac is supplied to the filament of rectifier V1 from terminals 6 and 7 on transformer T1. The high voltage from the secondary winding of transformer T1, appearing at terminals 3 and 5, is applied to the plates of full-wave rectifier V1 to provide B-plus voltage for control diode V2A and control amplifier V3. Center tap terminal 4 is grounded and +450 volts dc from the cathode of rectifier VI is applied to bypass capacitor C4, resistors R4 and R5, and terminal 4 of saturable reactor L1. Dc control current for saturable reactor L1 entering at terminal 4, flows through the dc control winding to terminal 5 and then from the plate to the grounded cathode of control amplifier V3. Resistor R4 in series with parallel resistors R9, R10, and R11 forms a voltage divider between the B-plus potential and ground. Screen grid voltage for control amplifier V3 is obtained from the common junction of these resistors. Resistor R5 in series with parallel resistors R6 and R7 connected across terminals 4 and 5 of saturable reactor L1 absorbs inductive voltage surges caused by sudden changes in the control current. Plate voltage at the common junction of resistors R5, R6 and R7 is bypassed to ground through resistor R8 in series with capacitor C1, and is also applied through resistor R12 to the plate of control diode V2A. Selenium rectifier CR1 converts the large ac potential existing at terminal 5 on transformer T1 to a negative 400-volt dc bias voltage. This bias voltage is filtered by series resistor R14 and bypass capacitor C5 and is applied to the cathode of control diode V2A. Resistor R15 is the negative bias supply load resistor. Control diode V2A is operated in a temperature limited condition so that its plate voltage varies greatly with filament temperature. The plate of diode V2A is connected through resistor R13 to the signal grid of control amplifier V3. Any variation in the plate potential of V2A, therefore, changes the plate current of V3 which also flows through the dc control winding of variable reactor L1. This changes the impedance of the variable reactance windings of reactor L1, which in turn alters the voltage applied to autotransformer T3 and consequently the output voltage of the regulator. VOLTS ADJ resistor R16 is adjusted so that the filament temperature and therefore the plate voltage of diode V2A is such as to produce the desired regulator output voltage of 230 volts ac. Any decrease in regulator output voltage caused by decreased supply voltage or increased load current will reduce the voltage applied to transformer T1, thereby reducing the filament voltage of control diode V2A. As a result, the diode plate current decreases, and the plate voltage assumes a more positive value. This increase in voltage, applied to the signal grid of control amplifier V3, increases its plate current which also flows through the dc control winding of saturable reactor L1. The impedance of the variable reactance windings is thereby reduced, so that a larger proportion of the line voltage is applied across input terminals 1 and 3 of autotransformer T3. Consequently, the output voltage at terminal 4 is increased by the amount necessary to restore the normal regulator output voltage. Any increase in the regulator output voltage, due to increased supply voltage or decrease in regulator load, is corrected by a similar but inverse process. In this case the voltage applied to transformer T1 increases, causing a drop in the plate voltage of control diode V2A and the signal grid voltage of control amplifier V3. As a result, the dc control current in saturable reactor L1 decreases, thereby increasing the series impedance of the variable reactance windings to reduce the line voltage applied to autotransformer T3. Resistor R1 improves the stability of the regulator output voltage against changes in the regulator load. Resistor R3 improves the stability of the regulator output against changes in regulator supply voltage. The voltages across these resistors are applied through transformer T2 to the control diode filament circuit. These voltages compensate the filament temperature to improve the stability of the regulator output voltage. Resistors R1 and R3 are adjusted at the time of manufacture to obtain optimum stability of the regulator output against varying supply voltage and output load. Control diode V2 is a type 2AS15 special purpose diode equipped with an internal shorting device to prevent the regulator output voltage from increasing because of a burned out diode




NOTES:

1. RESISTORS ARE IN OHMS, CAPACITORS ARE IN UF.
2. ALL CONNECTIONS SHOWN AS OPTIONAL CONNECTIONS ARE MADE AT TIME OF MANUFACTURE AND SHOULD NOT BE CHANGED EXCEPT AS REQUIRED AT FINAL TESTING.
3. RESISTORS R1, R3, R18, AND R19 ARE INDIVIDUALLY ADJUSTED AT TIME OF MANUFACTURE FOR EXACT VALUE REQUIRED. VALUES SHOWN ARE NOMINAL.
4. ▭ DENOTES EQUIPMENT MARKING.

TM2245-341

*Figure 144. Voltage regulator, schematic diagram.*

filament. When the filament fails, the internal shorting device connects the diode plate to the —400-volt bias potential thereby applying a large negative bias to the signal grid of control amplifier V3 to stop plate current flow. The interruption of this current flowing through the dc winding of saturable reactor L1 increases the impedance of the variable reactance windings to their maximum value so that minimum voltage is applied to autotransformer T3. Selenium rectifier CR2 prevents the signal grid of control amplifier V3 from assuming a positive potential which would cause an abnormal increase in regulator output voltage. Bleeder resistor R2 prevents damage to the regulator circuits when the external regulator load is removed.

## Section XIV. THEORY OF DC POWER DISTRIBUTION CIRCUITS

### 216. General

The dc power distribution circuits consist of the B-plus voltage distribution circuits and the loop battery voltage distribution circuits.

*a. B-plus Voltage Distribution Circuits.* Most of the electronic components in the AN/FGC–29 terminal contain power supplies for developing the B-plus and bias voltages necessary for their operation. The transmitters in the transmitting terminal and the combiners in the receiving terminal are exceptions and require an external source of B-plus voltage.

*b. Loop Battery Voltage Distribution Circuits.* Loop battery voltages of —130 volts dc orginate in loop battery supplies associated with the LOOP BATTERY PANEL. The loop battery voltages are supplied to the transmitters and combiners for operation of the dc telegraph loops and the associated AN/FGC–29 terminal circuits. A RELAY PANEL (par. 223) is used with loops requiring loop battery voltages other than —130 volts dc.

### 217. Transmitting Terminal, B-plus Voltage Distribution

(fig. 145)

The transmitters are the only component in the transmitting terminal that require an external source of B-plus voltage. This voltage is supplied from the LEVEL CONTROL and PLATE SUPPLY (par. 169). Two power supplies in the LEVEL CONTROL and PLATE SUPPLY each normally supply B-plus for eight transmitter channels. Channels 1 through 8 are normally supplied by power supply A and channels 9 through 16 are normally supplied by power supply B. In the event of failure of either power supply the remaining power supply may be switched by CHANNELS 1–8 and AMPL A ON POWER SUPPLY switch S2, or CHANNELS 9–16 and AMPL B ON POWER SUPPLY switch S3 to supply all 16 transmitter channels. A failure indicator circuit in the LEVEL CONTROL and PLATE SUPPLY, consisting of crystal diode CR1 shunted by PLATE SUPPLY A FAILURE indicator I7, and crystal diode CR2, shunted by PLATE SUPPLY B FAILURE indicator I8, respectively, indicates the failure of the corresponding power supply. If power supply A fails, current flows from power supply B to ground in power supply A, bypassing indicator I8 through diode CR2 in the conducting direction, and flowing through PLATE SUPPLY A FAILURE indicator I7, causing it to glow. If power supply B fails, current flows from power supply A to ground through CR1 in the conducting direction and PLATE SUPPLY B FAILURE indicator I8, causing it to glow. The B-plus voltage for channels 1 to 8 leaves at terminal E, and for channels 9 to 16 at terminal F of connector J18 of the LEVEL CONTROL and PLATE SUPPLY, and plug P111. The B-plus voltage for channels 1 to 8 continues through cable W111, terminal 5 of terminal board TB111, terminal 6 of terminal boards TB113 through TB116, associated cables W113 through W116, to terminal F of plugs P113 through P116 and connector J16 on TRANSMITTER CHANNELS 1 and 2 through TRANSMITTER CHANNELS 7 and 8. The B-plus voltage for channels 9 through 16 leaves at terminal F of connector J18 on the LEVEL CONTROL and PLATE SUPPLY and plug P111. The B-plus voltage continues through cable W111, terminal 6 of terminal board TB111 and terminal boards TB117 through TB120, associated cables W117 through W120. to terminal F of plugs P117 through P120, and connector J16 on TRANSMITTER CHANNELS 9 and 10 through TRANSMITTER CHANNELS 15 and 16.

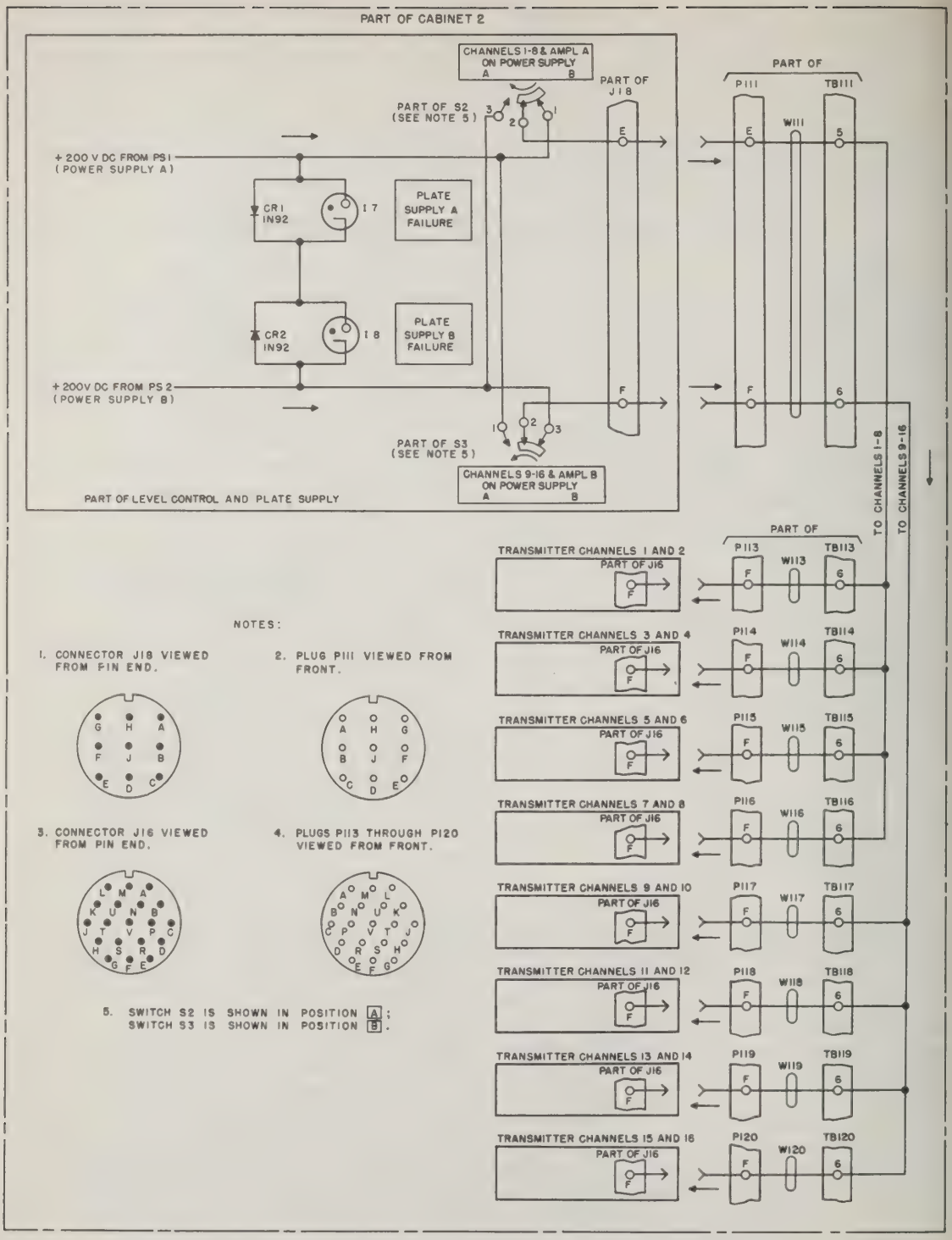



*Figure 145. Transmitting terminal, B-plus voltage distribution, schematic diagram*

## 218. Receiving Terminal, B-plus Voltage Distribution
(fig. 146)

The combiners are the only components in the receiving terminal which require an external source of B-plus voltage. Each combiner receives B-plus voltage from its two associated receivers. For example, COMBINER CHANNELS 1 and 2, receives B-plus voltage from RECEIVER CHANNEL 1 for its channel 1 circuits, and from RECEIVER CHANNEL 2 for its channel 2 circuits. Figure 146 is a schematic diagram of the receiving terminal B-plus distribution circuits. In cabinet 4, the B-plus voltage from receiver channels 1 through 6 leaves at terminal C of connector J16, through plugs P111, P113, P114, P116, P118, and P120, respectively, passing through associated cables W111, W113, W114, W116, W118, and W120, to terminal 3 of terminalboards TB111, TB113, TB114, TB116, TB118, and TB120. The B-plus voltage from receiver channels 1, 3, and 5 continues through terminal 8 of terminal boards TB112, TB115, and TB119, respectively, associated cables W112, W115, and W119 to terminal H of plugs P112, P115, P119, and connector J10 in the associated combiner channels 1, 3, and 5. The B-plus voltage from receiver channels 2, 4, and 6 continues through terminal 9 of terminal boards TB112, TB115, and TB119, respectively, associated cables W112, W115, and W119, and terminal J of plugs P112, P115, P119, and connector J10 in the associated combiner channels 2, 4, and 6. In cabinet 5, the B-plus voltages from receiver channels 7 through 10 leave at terminal C of connector J16 through plugs P114, P116, P118, and P120, respectively, associated cables W114, W116, W118, and W120, to terminal 3 of terminal boards TB114, TB116, TB118, and TB120. The B-plus voltage from receiver channels 7 and 9 continues through terminal 8 of terminal boards TB115 and TB119, respectively, and associated cables W115 and W119, to terminal H of plugs P115, P119, and connector J10 on associated combiner channels 7 and 9. B-plus voltages from receiver channels 8 and 10 continue through terminal 9 of terminal boards TB115 and TB119, respectively, associated cables W115 and W119, to terminal J of plugs P115 and P119, and connector J10 on associated combiner channels 8 and 10. In cabinet 6, the B-plus voltage from receiver channels 11 through 16 leaves at terminal C of connector J16 and plugs P111, P113, P114, P116, P118, and P120, respectively, passing through associated cables W111, W113, W114, W116, W118, and W120, to terminal 3 of terminal boards TB111, TB113, TB114, 'B116, TB118, and TB120. B-plus voltage from receiver channels 11, 13, and 15 continues through terminal 8 of terminal boards TB112, TB115, and TB119, associated cables W112, W115, and W119, to terminal H of plugs P112, P115, P119, and connector J10 on associated combiner channels 11, 13, and 15. B-plus voltage from receiver channels 12, 14, and 16, continues through terminal 9 of terminal boards TB112, TB115, and TB119, respectively, associated cables W112, W115, and W119, to terminal J of plugs P112, P115, P119, and connector J10 in associated combiner channels 12, 14, and 16.

*Figure 146. Receiving terminal, B-plus voltage distribution, schematic diagram.*

(Contained in separate envelope)

## 219. Transmitting Terminal, Loop Battery Distribution
(fig. 147)

The −130 volts dc loop battery voltages are generated in two loop battery supplies, designated as RECTIFIER A and RECTIFIER B (par. 222), which are connected to the LOOP BATTERY PANEL (par. 221) for distribution. The loop battery supplies and LOOP BATTERY PANEL are located in cabinet 1. Each loop battery supply is capable of supplying all sixteen transmitting loops, but is usually arranged to supply eight loops according to the setting of the FALL BACK SWITCHES described in paragraph 221. The loop battery voltages for channels 1 through 16 leave the LOOP BATTERY PANEL at terminals A through S of connector J1 and plug P120, and continue through cable W120 to terminals 1 through 10 of terminal board TB105 and terminals 1 through 6 of terminal board TB106, respectively. The loop battery voltages continue to cabinet 2 by way of terminals A through S, respectively, of connector J3 in cabinet 1, of plugs P151 and P152 of cable assembly W151 No. 1, and of connector J5 in cabinet 2. In cabinet 2 voltages for transmitting loops 1 through 16 pass through terminals 1 through 10 of terminal board TB107 and terminals 1 through 6 of terminal boards TB108, respectively, continue through terminals 3 and 4 of terminal boards TB113 through TB120, and associated cables

W113 through W120, and arrive at transmitters channels 1 through 16 at terminals C and D of plugs P113 through P120 and connector J16 in each transmitter. For a discussion of the application of loop battery voltages to the transmitting loops refer to the schematic diagram analysis of the transmitter (par. 218). Minus 130 volts from terminal 6 of terminal board TB106 in cabinet 1 is also applied to connector J7 of the TRANSMITTER METER PANEL by way of terminal 1 on terminal board TB112, cable W112, and plug P112. This voltage is required for the operation of the DOTTER circuit in the TRANSMITTER METER PANEL.

*Figure 147. Transmitting terminal, loop battery distribution, schematic diagram.*

(Contained in separate envelope)

## 220. Receiving Terminal, Loop Battery Distribution

(fig. 148)

The −130 volts dc loop battery voltages are generated in two loop battery supplies (par. 222) designated as RECTIFIER A and RECTIFIER B, which are connected to the LOOP BATTERY PANEL (par. 221) for distribution. The LOOP BATTERY PANEL and loop battery supplies are located in cabinet 3 of the receiving terminal. Each loop battery is capable of supplying 16 receiving telegraph loops but is usually connected to supply eight loops by FALL BACK SWITCHES S1 and S2 in the LOOP BATTERY PANEL as described in paragraph 221. The voltages for the 16 receiving telegraph loops leave the LOOP BATTERY PANEL at terminal A through S of connector J1 and plug P120 and continue through cable W120 to terminals 1 through 10 of terminal board TB105 and terminals 1 through 6 of terminal board TB106, respectively. The loop battery voltages continue to cabinet 4 by way of terminals A through S, respectively, of connector J3 in cabinet 3, of plugs P151 and P152, of cable assembly W151 No. 3, and of connector J5 in cabinet 4. In cabinet 4, the loop battery voltages for receiving loops 1 through 6 pass through terminals 1 through 6 of terminal board TB107, terminals 3 and 4 of terminal boards TB112, TB115, and TB119, and associated cables W112, W115, and W119, arriving at combiners channels 1 through 6 at terminals C and D of plugs P112, P115, and P119, and connector J10 of each combiner. The loop battery voltages for receiving loops 7 through 10 pass through terminals 7 through 10 of terminal board TB107 and terminal board TB105, to connector J3, and for receiving loops 11 through 16 through terminals 1 through 6 of terminals boards TB108 and TB106 to connector J3. The voltages leave cabinet 4 at terminals G through S of connector J3 in cabinet 4, plugs P151 and P152, of intercabinet cable assembly W151 No. 5, and connector J5 in cabinet 5. In cabinet 5, the loop battery voltages for receiving loops 7 through 10 pass through terminals 7 through 10 of terminal board TB107 and terminals 3 and 4 of terminal boards TB115 and TB119, associated cables W115 and W119, and terminals C and D of plugs P115, P119, and connectors J10 on combiner channels 7 through 10. Loop battery voltages for receiving loops 11 through 16 from terminal L through S of connector J5 pass through terminals 1 through 6 of terminal boards TB108 and TB106, and leave cabinet 5 by way of terminals L through S of connector J3 in cabinet 5, plugs P151 and P152 of intercabinet cable assembly W151 No. 7 and connector J5 in cabinet 6. In cabinet 6 these voltages continue through terminals 1 through 6 of terminal board TB108, terminals 3 and 4 of terminal boards TB112, TB115, and TB119, associated cables W112, W115, and W119 arriving at combiners channels 11 through 16 at terminals C and D of plugs P112, P115, P119 and connector J10 on each combiner.

*Figure 148. Receiving terminal, loop battery distribution, schematic diagram.*

(Contained in separate envelope)

## 221. Theory of LOOP BATTERY PANEL

(fig. 149)

The LOOP BATTERY PANEL in cabinet 1 of the transmitting terminal accepts 115 volts at 50 or 60 cps and distributes it to loop battery supplies RECTIFIER A and RECTIFIER B (par. 222). The −130 volts dc outputs of the loop battery supplies are also accepted and applied to individual loop battery outputs for distribution to transmitter channels 1 through 16 (par. 219). The LOOP BATTERY PANEL in cabinet 3 of the receiving terminal performs the same functions for combiner channels 1 through 16 (par. 220). For details of the loop battery distribution, refer to the loop battery distribution diagrams for the transmitting terminal (fig. 147) and for the receiving terminal (fig. 148). For details of the ac power distribution refer to the ac power

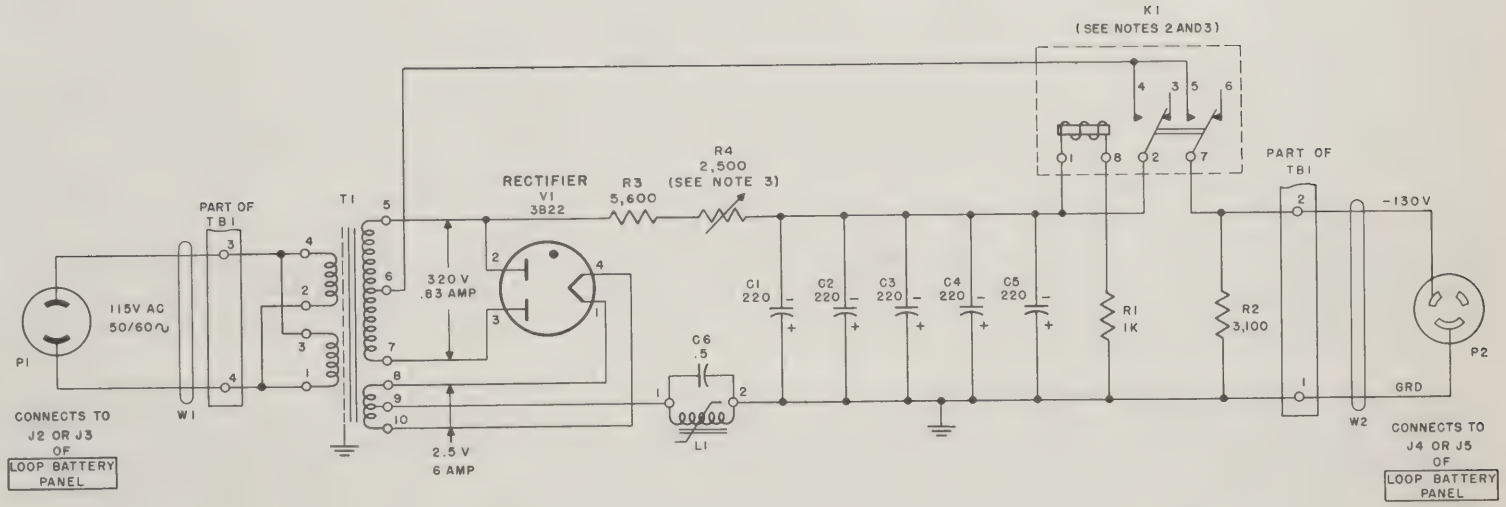
distribution diagrams for the transmitting terminal (fig. 260) and the receiving terminal (fig. 261). The ac input at 115 volts, 50 or 60 cps, enters the LOOP BATTERY PANEL at connector J6 and is applied to connectors J2 and J3. The line to connector J2 is fused by INPUT FUSES F19 and F20, bridged by BLOWN FUSE INDICATORS I19 and I20. The line to connector J3 is fused by INPUT FUSES F21 and F22, bridged by BLOWN FUSE INDICATORS I21 and I22. When a fuse blows the associated indicator glows. Connector J2 applies ac input power to plug P1 of RECTIFIER A and connector J3 to plug P1 of RECTIFIER B. The −130 volts from plug P2 of RECTIFIER A is accepted at connector J4 of the LOOP BATTERY PANEL, and from plug P2 of RECTIFIER B at connector J5. Both inputs are applied to FALL BACK SWITCHES S1 and S2. A failure indicator arrangement composed of crystal diode CR1 and RECTIFIER A FAILURE INDICATOR I23 indicates loss of input from RECTIFIER A. An identical arrangement of crystal diode CR2 and RECTIFIER B FAILURE INDICATOR I24 performs the same function for the input from RECTIFIER B. When RECTIFIER A fails, current flows from ground through FAILURE INDICATOR I23, causing it to glow, and then through diode CR2 to the −130 volts potential from RECTIFIER B. Conversely, when RECTIFIER B fails, current flows from ground through FAILURE INDICATOR I24, causing it to glow, and then through diode CR1 to the −130 volts potential from RECTIFIER A. The input from rectifiers A and B are applied to both FALL BACK SWITCHES S1 and S2. Switch S1 supplies power to LOAD A (LOOPS 1–8) for channels 1 through 8. Switch S2 supplies power to LOAD B (LOOPS 9–16) for channels 9 through 16. Switch S1 is normally in the RECT A position and switch S2 in the RECT B position, so that RECTIFIER A furnishes power to loops 1 through 8 and RECTIFIER B to loops 9 through 16. If either rectifier fails, its load can be transferred to the remaining rectifier by reversing the appropriate switch (S1 or S2) to maintain operation of all 16 loops. If RECTIFIER A fails both switches are set in the RECT B position and if RECTIFIER B fails both switches are set in the RECT A position. The LOOP BATTERY PANEL outputs for loops 1 through 8 on terminals A through H of connector J1 receive −130 volts dc power from switch S1 and are fused by LOOP FUSES 1 through 8 bridged by BLOWN FUSE INDICATORS I 1 through I8. The outputs for loops 9 through 16 on terminals J through S of connector J1 receive power from switch S2 and are fused by LOOP FUSES 9 though 16 bridged by BLOWN FUSE INDICATORS I9 through I16. If any loop fuse blows, its corresponding indicator will glow when the loop is in the marking condition.

*Figure 149. LOOP BATTERY PANEL, schematic diagram.*

(Contained in separate envelope)

## 222. Theory of Loop Battery Supply
(fig. 150)

The loop battery supply is a full-wave rectifier which accepts a 115-volt input at 50 or 60 cps from the LOOP BATTERY PANEL and delivers an output of +130 volts to the LOOP BATTERY PANEL. The ac input enters at terminals 1 and 2 of plug P1, passes through terminals 3 and 4 of terminal board TB1, and is applied to the parallel-connected primary windings of transformer T1 between terminals 1 and 3 and between terminals 2 and 4. The voltage developed between secondary terminals 5 and 7 is applied to the plates of rectifier V1. Heater voltage at 2.5 volts ac for the filamentary cathode of tube V1 is developed between terminals 8 and 10 of a separate secondary winding. Time delay relay K1 prevents application of the rectifier load until the filament of tube V1 is at operating temperature. When ac power is first applied, relay K1 is deenergized, and the rectifier load is disconnected. Current limiting resistors R3 and R4 connect between capacitors C1 through C5 and terminal 5 of transformer T1. This is a half-wave rectifier circuit in which the secondary voltage across terminals 5 and 7 of transformer T1 is rectified by one plate (terminal 3) and the cathode of rectifier V1 and applied across capacitors C1 through C5 in series with resistors R3 and R4. As rectifier V1 heats up a small rectified current flows from its filament through terminal 9 of transformer T1, inductor L1, capacitors C1 through C5, and resistors R4 and R3 to terminal 5 of the transformer. The charging current to the capacitors is limited by resistors R3 and R4 so that the voltage across the capacitors increases slowly. Resistor R1 in series with the operating winding of relay K1 at terminals 1 and 8 connects across the filter capacitors. When the voltage across the capacitors approaches 130 volts,

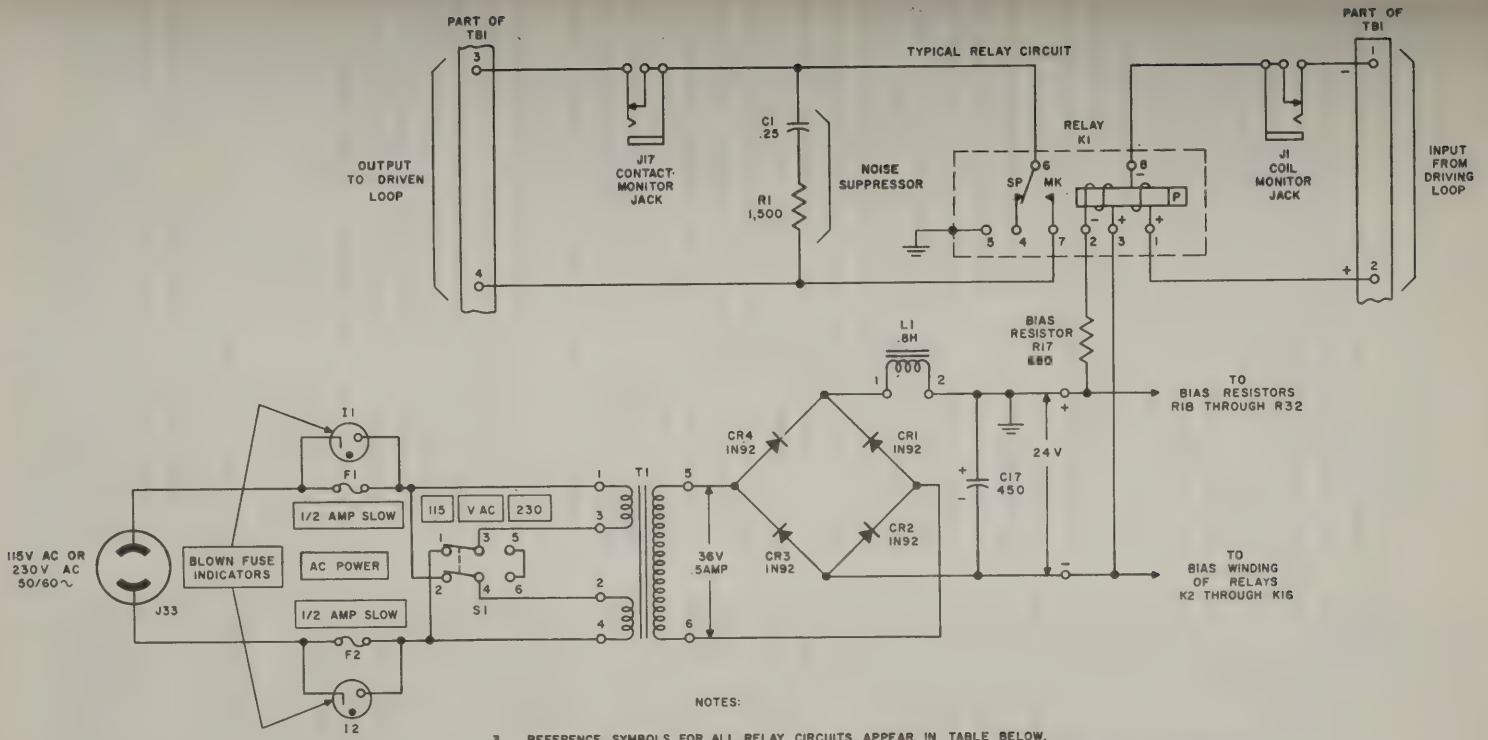



NOTES:

1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UF.
2. RELAY K1 IS SHOWN IN THE DE-ENERGIZED CONDITION.
3. RESISTOR R4 IS ADJUSTED TO OBTAIN A MINIMUM TIME DELAY OF 20 SECONDS IN THE OPERATION OF RELAY K1.

TM2245-98

*Figure 150. Loop battery supply, schematic diagram.*




NOTES:

1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UF.

2. [ ] DENOTES EQUIPMENT MARKING.

3. REFERENCE SYMBOLS FOR ALL RELAY CIRCUITS APPEAR IN TABLE BELOW.

| RELAY | DRIVING LOOP | | COIL MON JACK | BIAS RESISTOR | NOISE SUPPRESSOR | | CONTACT MON JACK | DRIVEN LOOP | |
|---|---|---|---|---|---|---|---|---|---|
| | TB | TERM. | | | CAP. | RES | | TB | TERM. |
| K1 | 1 | 1,2 | J1 | R17 | C1 | R1 | J17 | 1 | 3,4 |
| K2 | 1 | 5,6 | J2 | R18 | C2 | R2 | J18 | 1 | 7,8 |
| K3 | 1 | 9,10 | J3 | R19 | C3 | R3 | J19 | 1 | 11,12 |
| K4 | 1 | 13,14 | J4 | R20 | C4 | R4 | J20 | 1 | 15,16 |
| K5 | 2 | 1,2 | J5 | R21 | C5 | R5 | J21 | 2 | 3,4 |
| K6 | 2 | 5,6 | J6 | R22 | C6 | R6 | J22 | 2 | 7,8 |
| K7 | 2 | 9,10 | J7 | R23 | C7 | R7 | J23 | 2 | 11,12 |
| K8 | 2 | 13,14 | J8 | R24 | C8 | R8 | J24 | 2 | 15,16 |
| K9 | 3 | 1,2 | J9 | R25 | C9 | R9 | J25 | 3 | 3,4 |
| K10 | 3 | 5,6 | J10 | R26 | C10 | R10 | J26 | 3 | 7,8 |
| K11 | 3 | 9,10 | J11 | R27 | C11 | R11 | J27 | 3 | 11,12 |
| K12 | 3 | 13,14 | J12 | R28 | C12 | R12 | J28 | 3 | 15,16 |
| K13 | 4 | 1,2 | J13 | R29 | C13 | R13 | J29 | 4 | 3,4 |
| K14 | 4 | 5,6 | J14 | R30 | C14 | R14 | J30 | 4 | 7,8 |
| K15 | 4 | 9,10 | J15 | R31 | C15 | R15 | J31 | 4 | 11,12 |
| K16 | 4 | 13,14 | J16 | R32 | C16 | R16 | J32 | 4 | 15,16 |

TM2245-389

*Figure 151. RELAY PANEL, schematic diagram.*

relay K1 closes, connecting the rectifier to load resistor R2 and the external load through relay terminals 7 and 5 and connecting the negative sides of capacitors C1 through C5 to the center tap of transformer T1 (terminal 6). This arranges the circuit as a full-wave rectifier with resistors R3 and R4 connected across terminals 5 and 6 of the transformer. The time required for the charge across capacitors C1 through C5 to build up to a voltage which will operate relay K1 is adjusted by setting variable resistor R4 to obtain a minimum time delay of 20 seconds. This delay is sufficient to permit the filament of rectifier V1 to reach operating temperature. On the positive half-cycle of applied voltage, one plate of rectifier V1 conducts, and in the negative half-cycle, the second plate conducts. A pulsating dc voltage is developed between the common cathode connection (terminal 9) and terminal 6 of the transformer secondary. This dc is applied through the rectifier consisting of inductor L1 and capacitors C1 through C5 to terminals 1 and 2 of terminal board TB1. Inductor L1 and capacitor C6 make up an antiresonant circuit which presents a high impedance to harmonics of the power frequency. Inductor L1 is a swinging choke whose inductance varies with its average current and provides some voltage regulation. The −130 volts between terminals 2 and 1 of terminal board TB1 is applied through plug P2 to the LOOP BATTERY PANEL (par. 221).

## 223. Theory of RELAY PANEL

(fig. 151)

The RELAY PANEL is a panel mounted assembly of 16 polar relays, furnished with the AN/FGC–29 terminal. These relays are used in telegraph loops which cannot operate directly into the AN/FGC–29 terminal because of special battery requirements or other considerations. The operating winding between terminals 1 and 8 of relays K1 through K16, in series with COIL jacks J1 through J16 are brought to terminals on the rear of the panel for connection to driving loops. The tongue and marking contacts on terminals 6 and 7 of relays K1 through K16 in series with CONTACT jacks J17 through J32 are brought to terminals on the rear of the panel for connection to driven loops. Spark suppression capacitors C1 through C16 in series with resistors R1 through R16 are connected between the tongue and marking contact of relays K1 through K16. The bias winding between terminals 2 and 3 of relays K1 through K16, in series with current limiting resistors R17 through R32, each receive 30 ma bias current from the power supply consisting of transformer T1, diodes CR1 through CR4, inductor L1 and capacitor C17. The current flow in each biasing winding is in the direction to hold the relay tongue on the spacing contact. With this arrangement, absence of current in the operating winding (a spacing signal) transmits a spacing signal to the driven loop. A current of 60 ma flowing in the operating winding (a marking signal) moves the relay tongue to the marking contact and transmits a marking signal to the driven loop. Of the 60 ma in the operating winding, 30 ma cancels the effect of the 30 ma current in the bias winding and the remaining 30 ma is available for driving the tongue from the spacing to the marking contact. The current flow in the operating winding must be in the opposite direction to the current flow in the biasing winding for this to happen. The driving loops must be connected to the terminal pairs on the rear of the RELAY PANEL for the operating windings of relays K1 through K16 so that the loop current enters by way of the even-numbered terminal and leaves by way of the odd-numbered terminal of the terminal pairs. COIL jacks J1 through J16 permit series connection to the operating winding of relays K1 through K16, respectively, for measurement of the driving loop current. CONTACT jacks J17 through J32 permit series connection to the contact circuit of relays K1 through K16, respectively, for measurement of the driven loop current.

# Section XV. THEORY OF AUXILIARY COMPONENTS

## 224. General

Auxiliary components furnished as part of the AN/FGC–29 terminal include a TRANSMITTER METER PANEL, a RECEIVER METER PANEL, and a DIVERSITY ALIGNMENT PANEL. These components contain metering and testing facilities used for the operation and maintenance of the AN/FGC–29 terminal.

## 225. TRANSMITTER METER PANEL, Block Diagram Analysis

(fig. 152)

The TRANSMITTER METER PANEL provides the metering facilities required for the routine operation and maintenance of the transmitting terminal, and also provides a source of bias-free telegraph dotting signals for test purposes. The panel contains two metering instruments, a LEVEL METER, and a LOOP CURRENT METER, and a source of signal reversals, or DOTTER. The LEVEL METER permits signal level measurements to be made on either a 14,000-ohm bridging, or 600-ohm terminating, bias. The LOOP CURRENT METER allows monitoring of 20 ma or 60 ma dc transmitting loops. The DOTTER supplies dc spacing, marking, or dotting signals, which may be patched to any transmitter channel to simulate dc loop signals for testing purposes.

*a. LEVEL METER Circuit.* The LEVEL METER circuit measures signal levels at various points in the receiving terminal on a bridging or terminating basis. The instrument is designed for use with 600-ohm audio-frequency circuits in the range from 250 to 6,000 cps. For a 0-vu scale reading, the sensitivity range is +10 dbm to −28 dbm. When the LEVEL METER circuit is arranged as a bridging meter, the input impedance of the circuit is 14,000 ohms; when arranged as a terminating meter the impedance is 600 ohms. When the LEVEL METER circuit is used as a bridging meter, signals to be measured are patched to BRIDGING jacks J1 and J2 using a cord equipped with twin plugs. For measurement on a terminating basis the signals are patched to TERMINATING jacks J3 and J4. From the jacks, the signal is coupled by way of input transformer T1 to the 3,900-ohm adjustable Attenuator AT1. Transformer T1 matches the impedance of the input circuit to the impedance of the attenuator. Attenuator AT1 adjusts the signal level applied to first amplifier V1A for a convenient reading on LEVEL METER M1. The power level in dbm, of the signal being measured is equal to the attenuator knob setting plus the meter reading. This is true only for 600-ohm circuits. On circuits of other than 600-ohm impedance, the measurements are only relative and not absolute. Attenuator AT1 has a maximum attenuation of 38 db in steps of 2 db. The signal from first amplifier V1A enters an interstage shaping network consisting of resistor R8 and capacitor C2, which attenuates frequencies above the passband of the LEVEL METER circuit. From the interstage network the signals are amplified by second amplifier stage V1B and enter an interstage network including resistors R12 and R13, and capacitors C4 and C6. This network attenuates frequencies above and below the passband of the circuit. The signal is next applied successively to third and fourth amplifier stages V2A and V2B. The gain of the amplifier stages is stabilized by voltage feedback from the output of V2B through voltage feedback resistor R7 to first amplifier stage V1A. The signals are coupled from fourth amplifier stage to LEVEL METER M1 by output transformer T2. The LEVEL METER circuit contains its own power supply. Input power at 115 volts ac, 50 or 60 cps, is applied through power switch S2 and transformer T3 to rectifier V3. This tube supplies B-plus voltage of 165 volts dc to amplifier tubes V1 and V2. The B-plus voltage is filtered by a network made up of resistors R22 and R23 and capacitors C8A and C8B. Transformer T3 also supplies 6.3 volts ac to PWR IND I3 and the heaters in tubes V1, V2, and V3. Indicator I3 glows when ac is present in the heater circuit.

*b. LOOP CURRENT METER Circuit.* Telegraph loop signals to be monitored are patched to the INPUT jack with a cord equipped with single plug and are applied to MILLIAMPERES switch S3. Switch S3 arranges the LOOP CURRENT METER circuit for either a 30-ma or 90-ma range. The 90-ma range is used for monitoring 60-ma loops, and the 30-ma range is used for monitoring 20-ma loops. The signals are next applied to a meter resistor network composed of resistors R25 through R29 which proportions the meter current to make the scale reading on both ranges equal to the loop current under measurement. The combination of BIAS switch S4 and damping capacitor C9 across a portion of the resistor network doubles the sensitivity of the meter when the switch is operated, and applies heavy damping to give a steady reading when measuring signal bias.

*c. DOTTER Circuit.* The signal input for the DOTTER circuit is an 115-volt, 50- or 60-cps signal, applied from transformer T3 in the LEVEL METER circuit to transformer T4 in the DOTTER circuit. A 90-volt signal from transformer T4 is applied to clipper amplifier V4A. On the positive half-cycle on the input signal, amplifier

V4A conducts and delivers a large negative pulse to the multivibrator circuit which follows. On the negative half-cycle of the input signal the clipper amplifier is cutoff and delivers a small positive pulse to the multivibrator. Tubes V5A and V5B form a multivibrator circuit that has two stable conditions. The circuit is stable when tube V5A is conducing and tube V5B is cutoff, and also when tube V5B is conducting and tube V5A is cutoff. The multivibrator remains in one or the other of these stable conditions until some action occurs which causes the conducting tube to be cutoff and the circuit to switch to its second stable condition. The large negative pulse from the clipper amplifier triggers the multivibrator to reverse its stable condition. The positive pulse has no effect on the multivibrator circuit and it remains in one or the other of its stable conditions during the periods between negative input pulses. One complete output cycle of the multivibrator results for each two negative input pulses. The multivibrator output therefore has a frequency one-half that of the signal applied to the DOTTER circuit input. The multivibrator output is applied to parallel-connected first and second output amplifiers V6 and V7, through buffer amplifier V4B and a clamping circuit. The clamping circuit, consisting of crystal diode CR1, capacitor C17, and resistor R43, prevents blocking of the signal due to grid conduction in the output amplifier stages. The amplified signals are taken from tubes V6 and V7 and applied to MARK-SPACE-DOT switch S5. From switch S5 the signals pass through METER jack J8 to OUTPUT jack J9. Switch S5 has three positions. In the MARK position, the first and second output amplifiers are held in the conducting condition, so that the dotting signals are blocked, and a steady marking signal is applied to the OUTPUT jack. In the SPACE position, the dotting signals from the output amplifiers are diverted to ground, and a spacing signal is available at the OUTPUT jack. In the DOT position, the dotting signals from the output amplifiers are applied to the OUTPUT jack. DOT FREQUENCY indicator I5 is bridged between switch S5 to ground. Indicator I5 glows whenever a signal voltage is applied to the METER jack. A steady marking signal produces a steady indicator glow, a spacing signal extinguishes the lamp, and a dotting signal produces a flicker at the repetition rate of the dotting signals. The output of the DOTTER circuit at the OUTPUT jack is available for patching to any transmitter channel with a cord equipped with single plugs. Heater voltages of 6.3 volts ac for tubes in the DOTTER circuit are furnished from transformer T4. Plate potential for tubes in the DOTTER circuit is furnished by −130 volts from the LOOP BATTERY PANEL.

*Figure 152. TRANSMITTER METER PANEL, block diagram.*

(Contained in separate envelope)

## 226. TRANSMITTER METER PANEL, Schematic Diagram Analysis

(fig. 153)

The circuits of the TRANSMITTER METER PANEL are shown in detail on the schematic diagram (fig. 153). A detailed discussion of the LEVEL METER circuit is given in *a* below, the LOOP CURRENT METER circuit in *b* below, and the DOTTER circuit in *c* below.

*a. LEVEL METER Circuit.* When using the LEVEL METER to measure signal levels on a bridging basis, BRIDGING jacks J1 and J2 are patched across the signal circuit. The impedance presented to the circuit being measured consists of the impedance of resistors R2 and R3 in series with the primary impedance of transformer T1 and is approximately 14,000 ohms. When using the LEVEL METER to measure signal levels on a terminating basis, the signal circuit is terminated in TERMINATING jacks J3 and J4. This action connects resistor R1 across the input circuit of the LEVEL METER to reduce its input impedance to 600 ohms to terminate the signal circuit correctly. Capacitor C1 is a blocking capacitor which removes any dc voltage which may exist on the signal circuit being measured. Signals are applied to terminals 1 and 2 of transformer T1 which matches the impedance of the input circuit to the 3,900-ohm attenuator which follows. Signals from terminals 3 and 4 of transformer T1 are applied to attenuator AT1 at terminals 1 and 2. Attenuator AT1 is a 38-db attenuator adjustable in 2-db steps, which controls the level of the signals entering the amplification stages which follow. Signals leave the attenuator at terminals 3 and 2, and are applied to the grid of first amplifier V1A across resistor R4. Resistor R4 supplies the terminating impedance for attenuator AT1. Resistor R6 is the cathode-biasing resistor and resistor R5 is the plate load resistor for tube V1A. Signals from the plate of V1A are applied to the grid of second amplifier

V1B across the interstage shaping network made up of resistor R8 and capacitor C2, and through coupling capacitor C3. Resistor R8 and capacitor C2 in series attenuate frequencies above the signal band. Resistor R9 is the grid resistor, resistor R10 the plate load resistor, and resistor R11 the cathode-biasing resistor for the second amplifier stage. The signal is next applied across a second interstage shaping network consisting of resistor R12 in series with capacitor C4. The network is connected across the signal circuit and attenuates frequencies above the signal band. Capacitor C5 passes the signals to the grid of third amplifier V2A through the interstage shaping network made up of resistor R13 shunted by capacitor C6. This network attenuates frequencies below the signal band. Resistor R14 is the grid resistor, resistor R15 is the plate load resistor, and resistor R16 provides cathode-bias. Signals from the plate of tube V2A are coupled to the grid of fourth amplifier V2B through coupling capacitor C7. Resistor R17 is the grid resistor and resistor R18 furnishes cathode-bias for the stage. The primary of transformer T2 constitutes the plate load impedance. Negative voltage feedback is furnished from the plate of tube V2B through feedback resistor R7 to the cathode of tube V1A to stabilize the overall amplifier gain and output impedance. Signals from the plate of tube V2B are applied to transformer T2 at primary terminals 1 and 2. Transformer T2 has an impedance ratio of 10,000- to 600-ohms to match the impedance of the amplifier output to the impedance of the meter circuit. Signals from terminals 3 and 4 of transformer T2 are applied across transformer terminating resistor R19 to LEVEL METER M1 through damping resistor R20 and calibrating variable resistor R21. The gain provided by the amplifier stages is precisely the amount required to produce a scale reading of 0 vu on LEVEL METER M1 when a signal of −28 dbm is applied to the input of the LEVEL METER circuit and Attenuator AT1 is set on −28 (zero loss). When the ATTENUATOR is set on +10 (38-db loss) a signal level of + 10 dbm at the input of the LEVEL METER circuit also produces a 0 vu scale reading on LEVEL METER M1. Carrier levels are therefore measured by adjusting Attenuator AT1 for a meter indication closest to zero on the scale. The attenuator setting plus the meter reading gives the carrier level in dbm. Power for the LEVEL METER is supplied by a power circuit which accepts an 115-volt ac input at 50 or 60 cps, and delivers an output of 165 volts dc for vacuum tube plate circuits, and 6.3 volts ac for the heater circuits. The ac input enters at connector J6 and is applied to AC POWER switch S2, a double-pole, single-throw switch with ON and OFF positions. Power is applied to transformer T3 at terminal pairs 1–2 and 3–4 from switch S2 through AC POWER fuses F1 and F2. Fuses F1 and F2 protect the LEVEL METER circuits from overload. BLOWN FUSE INDICATORS I 1 and I2, bridged across fuses F1 and F2, respectively, glow when the corresponding fuse blows. Input for rectifier V3 is taken from terminal 7 of transformer T3 with terminal 9 grounded. Rectifier T3 is used in a conventional half-wave rectifier circuit feeding the two-section plate supply filter consisting of resistor R22 and capacitor C8A, and resistor R23 and capacitor C8B. Resistor R24 is the load resistor. A positive voltage of 165 volts dc is supplied to the plate circuits of tubes V1 and V2 from the high end of resistor R24. Heater voltage at 6.3 volts ac for tubes V1, V2, and V3 is taken from a separate secondary winding on transformer T3 at terminals 5 and 6 (ground). PWR IND indicator I3 is bridged across the heater circuit and glows as long as ac power is present in the heater circuit.

*b. LOOP CURRENT METER Circuit.* Telegraph loop signals to be measured are patched to INPUT jack J5. MILLIAMPERES switch S3 sets the meter on a 90-ma range for monitoring 60-ma loops, or on a 30-ma range for monitoring 20-ma loops. When switch S3 is placed in the 30 position, resistors R25 and R26 are connected in series with the loop being measured. The resulting potential drop across these resistors causes a small current to flow from the sleeve of jack J5, through meter M2 and resistors R29, R28, and R27 back to the tip of jack J5. Meter M2 has a 100-microampere movement with separate 30-ma and 90-ma scales. Resistors R27, R28, and R29 limit the meter current so that the meter scale reading is equal to the loop current being measured. When switch S3 is placed in the 90 position, resistor R26 only is connected in series with the loop. The voltage drop across resistor R26 at 60 ma is identical to the drop across resistors R25 and R26 in series at 20 ma so that the meter deflection is the same in both cases. The resistance of resistor R25 is too small to effect the meter reading when S3 is in the 90 position. When BIAS switch S4 is closed, resistor R28 is shorted out and capacitor C9 is simulta-

neously connected into the circuit. Resistors R27, R28, and R29 are proportioned to double the meter current when R28 is shorted by switch S4. Capacitor C9, operating in conjunction with resistors R27 and R29, forms an integrating, or damping, circuit which effectively slows the meter response for bias measurements or adjustments on dotting signals. The LOOP CURRENT METER is used to check for bias on the transmitting loop signals by first adjusting the steady marking loop current to 20 or 60 ma as indicated by a red line on the meter scale. Dotting signals are then transmitted and BIAS switch S4 depressed to double the sensitivity of the meter. If the signals are unbiased, that is, marking and spacing intervals are equal, then the meter reading will remain unchanged.

*c. DOTTER Circuit.* Power voltage at 115 volts, 50 or 60 cps, applied to transformer T3 in the LEVEL METER circuit is also applied to the primary of transformer T4 in the DOTTER circuit. Heater voltage at 6.3 volts ac for tubes V4 through V7 is derived from secondary terminals 5 and 6 of transformer T4. Plate voltage for the dotter circuit is obtained by returning the plate circuits of the stages to ground and the cathode circuit to −130 volts dc. Ground and −130 volts potential enter the TRANSMITTER METER PANEL at polarized connector J7. The −130 volts battery is applied through fuse F3 bridged by BLOWN FUSE INDICATOR I4 to the negative side of the DOTTER circuit. When fuse F3 blows battery is applied across BLOWN FUSE INDICATOR I4 causing it to glow. A 90-volt ac input signal for the DOTTER circuit is supplied from terminals 7 and 8 of transformer T4 and applied to the grid of clipper amplifier V4A through grid current limiting resistor R30. During the positive half-cycle of the input signal, the grid-to-cathode resistance of the clipper amplifier drops to a low value compared with that of grid current limiting resistor R30 so that the grid voltage rise is limited to a value slightly positive with respect to the cathode. During this period the stage is fully conducting and an essentially constant plate current flows through plate resistor R31 causing the voltage at the plate of clipper amplifier V4A to assume a maximum and essentially constant negative potential. During the negative half-cycle of the input signal, the grid-to-cathode resistance of the stage is substantially infinite and the grid potential follows the input signal. During this period the grid is below plate current cutoff potential so that no plate current flows through plate resistor R31 and the voltage at the plate of clipper amplifier V4A returns to ground potential. The rate at which the plate returns to ground potential when V4A is suddenly cut off is relatively slow since the capacity of the circuits connected to the plate must charge through plate resistor R31. The rate at which the plate goes negative when V4A suddenly conducts is much higher since the circuit capacity discharges through the low plate-to-cathode impedance of the tube. Stages V5A and V5B make up a bistable multivibrator circuit. One stable condition exists when V5A is conducting with V5B cutoff, and the other when V5B is conducting with V5A cutoff. The circuit remains in one or the other of these two conditions until some action occurs which causes the conducting tube to be cut off. The tubes then immediately reverse their functions and remain in the new condition. Cathode-bias for both V5A and V5B is furnished by resistor R39 bypassed by capacitor C11. Since one or the other of the tubes is always conducting, the cathode-biasing voltage remains constant. When V5A is conducting the V5B is cut off, the plate current flowing through resistor R35 causes the voltage at the plate of V5A to assume its most negative value. Resistors R37 and R34 connected in series between the plate of V5A and −130 volts function as a voltage divider. The values of these resistors are so proportioned that the voltage applied from their common junction to the grid of V5B is sufficiently negative with respect to the cathode potential to prevent plate current flow in V5B. As a result, the voltage at the plate of V5B assumes its maximum positive value. Resistor R38 and R33 connected in series between the plate of V5B and −130 volts have the same resistance values as resistors R37 and R34 and also function as a voltage divider. Since the voltage at the plate of V5B is at its maximum positive value, the voltage applied to the grid of V5A from the common junction of resistors R38 and R33 is positive with respect to the cathode potential, maintaining the stage in the fully conducting condition. When clipper amplifier V4A suddenly conducts, its plate voltage abruptly decreases and a large negative voltage pulse passes through resistor R32 and capacitor C10 to the grid of V5A. Simultaneously, a similar pulse passes through resistor R40 and capacitor C14 to the grid of V5B. The negative pulse applied to the grid of conducting tube V5A drives the stage

to cutoff, producing a large and abrupt positive rise in its plate voltage which passes through capacitor C12 to the grid of V5B. As a result, tube V5B conducts, producing an abrupt decrease in its plate voltage which passes through capacitor C13 to the grid of stage V5A to maintain this stage in the nonconducting condition. The multivibrator remains in this condition since the voltage applied from the junction of resistors R37 and R34 to the grid of V5B is now positive with respect to its cathode. Tube V5A remains in the nonconducting state since the voltage applied from the junction of resistors R38 and R33 is now negative with respect to its cathode. When clipper amplifier V4A is suddenly cut off, its plate voltage rises and a positive pulse is applied to the grids of V5A and V5B. This pulse is much smaller than the negative pulse previously applied since the rate of increase of the plate voltage of V4A is relatively slow, and the peak amplitude of the pulse passed by capacitor C10 is insufficient to cause V5A to conduct. As a result, positive pulses from clipper amplifier V4A produce no effect on the multivibrator. The multivibrator is tripped from one stable condition to the other each time a negative pulse is applied. The multivibrator output signal is taken from the plate of V5A. If a negative pulse applied to the multivibrator changes the plate voltage of V5A from maximum to minimum, the succeeding negative pulse will change it from minimum to maximum so that one complete output cycle results for each two negative input pulses. Since clipper amplifier V4A puts out one negative pulse for each complete cycle applied to its grid, the output frequency of the multivibrator is one-half the input frequency applied to V4A. Since one negative pulse is produced for each cycle of the input signal, the time interval between negative pulses is constant. As a result, the time interval between reversals of the multivibrator output signal is identical (unbiased). Signals from the multivibrator are applied through capacitor C15 to grid resistor R41 and the grid of buffer amplifier V4B, a cathode follower stage. Resistor R42 is the cathode load resistor. Signals from the cathode of buffer amplifier V4B are applied through coupling capacitor C16 and resistor R44 to the control grids of first and second output amplifiers V6 and V7. Diode CR1, capacitor C17, and resistor R43 form a clamping circuit to prevent blocking of coupling capacitor C16 caused by control grid conduction in the output amplifiers during the positive intervals of the signal. Screen dropping resistor R47 limits the maximum screen current of tubes V6 and V7 to a safe value. Resistors R45 and R46 serve to suppress parasitic oscillations. MARK-SPACE-DOT switch S5 is shown in the DOT position in figure 153. Signals from the plates of V6 and V7 pass through terminals 12 and 9 of switch S5 and METER jack J8 to the tip of OUTPUT jack J9. The signals may be connected to the EQUIP jack of any transmitter channel in the AN/FGC–29 terminal by means of a cord equipped with a single plug inserted in OUTPUT jack J9. When the cord is removed from jack J9, the signals bypass switch S5 and pass through jack J9 and resistor R49 to ground. Switch S5 in the SPACE position removes the signals from the tip of jack J9 and applies them through contacts 3 and 1 of switch S5 to the upper spring contact of jack J9 so that the dotting signals pass through the jack and to ground through resistor R49 whether or not a plug is present in jack J9. Switch S5 in the MARK condition connects the control grids of V6 and V7 to −130 volts through contacts 6 and 5 of switch S5 thereby holding both tubes in the conducting (marking) condition. The marking signal from the plates of V6 and V7 is applied through contacts 10 and 9 of switch S5 and METER jack J8 to the tip of OUTPUT jack J9. When the plug of the patching cord is removed from jack J9 the marking signal passes to ground through resistor R49. METER jack J8 may be patched to INPUT jack J5 of the LOOP CURRENT METER to monitor the DOTTER output signals. A 60-cps signal input to the DOTTER produces a 30-cps output and a 50-cps input produces a 25-cps output. DOT FREQUENCY neon indicator lamp I5, connected between the DOTTER output and ground, glows during a marking signal and is extinguished during a spacing signal. On dotting signals the indicator flickers at 25- or 30-cps rate (discernible to the eye) indicating proper operation of the multivibrator.

*Figure 153. TRANSMITTER METER PANEL, schematic diagram.*

(Contained in separate envelope)

## 227. RECEIVER METER PANEL, Block Diagram Analysis

(fig. 154)

The RECEIVER METER PANEL provides the metering facilities required for routine opera-

tion and maintenance of the receiving terminal. The panel contains three test instruments, a LEVEL METER, a LOOP CURRENT METER, and a DELAY ADJUST METER. The LEVEL METER permits signal level measurements to be made on either a 14,000-ohm bridging or 600-ohm terminating basis. The LOOP CURRENT METER allows monitoring of 20-ma or 60-ma dc loops. The DELAY ADJUST METER permits delay equalization of channels operating in diversity. The RECEIVER METER PANEL as a self-contained unit operating on 230 volt ac, 50 or 60 cps.

*a. LEVEL METER Circuit.* The block diagram analysis of the LEVEL METER circuit in the RECEIVER METER PANEL is identical with the analysis of the corresponding circuit in the TRANSMITTER METER PANEL (par. 219) except that operating power is applied at 230 volts.

*b. LOOP CURRENT METER Circuit.* The block diagram analysis of the LOOP CURRENT METER circuit is identical with the analysis of the corresponding circuit in the TRANSMITTER METER PANEL (par. 219) with the following exception. INPUT jack J5 is modified so that the LOOP CURRENT METER is connected to LOOP CURRENT switch S5 of the DELAY ADJUST METER except when jack J5 is corded to a receiving telegraph loop.

*c. DELAY ADJUST METER Circuit.* The DELAY ADJUST METER is an indicating test instrument used to determine the proper settings of the DELAY ADJ controls (par. 183) associated with receivers operating in diversity to insure that diversity signals to be combined are subject to equal transmission delays, other than variable delays introduced by the radio transmission path, so that they arrive at the common combining section of the combiner exactly in phase. Dotting signals used to determine the proper setting of the DELAY ADJ controls of the receivers are sent from the transmitting end of the system through any pair of channels which can be operated in four-channel diversity. The signals are patched from the combiner odd- and even-numbered channel EQUIP jacks to the DELAY ADJUST METER circuit ODD CHANNEL and EVEN CHANNEL jacks, respectively, of the RECEIVER METER PANEL and applied to LOOP CURRENT switch S5. Switch S5 routes signals in either channel to the LOOP CURRENT METER circuit, and in both channels to the balance network. The balance network, consisting of resistors R30 and R33, produces signal voltages which are proportional to the difference between the odd-numbered and even-numbered channel loop currents. The signals enter BALANCE-DELAY switch S7. In the BALANCE position of switch S7, the signals are applied to DELAY ADJUST METER M3 through the combination of BALANCE SENSITIVITY switch S6 and resistor R40. Switch S6 is a momentary switch which, when operated, shorts resistor R40 out of the circuit, which increases the sensitivity of the meter for accurate balancing of the marking signal currents in the two loops. When making delay adjustments, dotting signals are transmitted over the radio circuit on both channels and switch S7 is placed in the DELAY position, so that the signal voltages are applied to switching varistor CR1 and associated resistors R34 through R37. The switching varistor operates in such a way as to cause current to flow through delay adjust resistors R38 and R39, integrating network resistor R41, and meter M3 when one channel signal is delayed with respect to the other. When the even-numbered channel is delayed with respect to the odd-numbered channel, the current flow through the meter causes it to deflect to the left. When the odd-numbered channel is delayed with respect to the even-numbered channel, the current flow through the meter causes it to deflect to the right. Adjustment of the DELAY ADJ control in the channel having the least delay, to equalize the delay between both channels, returns the meter to zero. The integrating network made up of resistor R41 and capacitors C12 and C13 minimizes the effect of random variations in the dotting signals caused by fading or noise in the radio path.

*Figure 154. RECEIVER METER PANEL, block diagram.*

(Contained in separate envelope)

## 228. RECEIVER METER PANEL, Schematic Diagram Analysis

(fig. 155)

The LEVEL METER circuit is discussed in *a* below, and the LOOP CURRENT METER circuit in *b* below. A detailed analysis of the DELAY ADJUST METER circuit is given in *c* below.

*Figure 155. RECEIVER METER PANEL, schematic diagram.*

(Contained in separate envelope)

*a. LEVEL METER Circuit.* The schematic diagram analysis of the LEVEL METER circuit is identical with the analysis of the corresponding circuit in the TRANSMITTER METER PANEL (par. 200*a*) with the following exceptions. Operating power applied to connector J6 is 230 volts and the primary windings of transformer T3 are connected in series. Power is applied to terminals 1 and 4 of transformer T3 and terminal 2 is strapped to terminal 3.

*b. LOOP CURRENT METER Circuit.* The schematic diagram analysis of the LOOP CURRENT METER circuit is identical with the analysis of the corresponding circuit in the TRANSMITTER METER PANEL (par. 200*b*) with the following exception. INPUT jack J5 is provided with extra springs and contacts which connect the LOOP CURRENT METER with the DELAY ADJUST METER circuit. When a receiving loop is corded to jack J5, the insertion of the plug breaks the connections to the DELAY ADJUST METER and connects the LOOP CURRENT METER in series with the loop being measured.

*c. DELAY ADJUST METER Circuit.* To use the DELAY ADJUST METER for equalizing the delay of diversity channels it is first necessary to adjust the odd-numbered and even-numbered channel marking loop currents from the combiner to approximately 60 ma and to match (balance) the loop currents within very close limits. Loop signals are taken from the even-numbered and odd-numbered channel EQUIP jacks of the combiner and corded to the corresponding EVEN CHANNEL and ODD CHANNEL jacks of the DELAY ADJUST METER. This action removes the combiner MONITOR jacks from the circuit. For this reason LOOP CURRENT switch S5 on the DELAY ADJUST METER permits the LOOP CURRENT METER to be connected to either the odd-numbered or even-numbered channel loop circuit for measurement of the individual loop currents. In the BALANCE position, BALANCE DELAY switch S7 permits accurate balancing of the marking loop currents. For loop current balancing, the IDLE-NORMAL switches of the combiner are both set on IDLE to hold the loops in the marking condition. For making delay adjustments, the IDLE-NORMAL switches are set in the NORMAL position so that the dotting signals, at 25 or 30 cps, from the distant transmitter are applied to the combiner EQUIP jacks.

(1) *LOOP CURRENT switch* (figs. 155 and 156). The LOOP CURRENT switch permits monitoring of loop current or bias in the LOOP CURRENT METER circuit when the DELAY ADJUST METER is in use. When the DELAY ADJUST METER is arranged for loop current balancing or delay adjustment the ODD CHANNEL and EVEN CHANNEL jacks are corded to the corresponding EQUIP jacks of the combiner. This disassociates the MONITOR jacks of the combiner from the combiner output circuit and renders them inoperative for monitoring. The monitoring if performed by routing the odd-numbered channel and even-numbered channel signals through the LOOP CURRENT METER circuit as described below. When a plug is present in INPUT jack J5 of the LOOP CURRENT METER circuit, the normals of the jack are open and the LOOP CURRENT METER circuit is disconnected from the LOOP CURRENT switch, so that the plug must be removed before the DELAY ADJUST METER can be used. The signals from jacks J7 and J8 are applied to LOOP CURRENT switch S5. In the ODD CHANNEL position of switch S5 the signals from the ODD CHANNEL jack are applied to terminal 2 and connected through terminal 1 to the LOOP CURRENT METER circuit by way of INPUT jack J5. After passing through the LOOP CURRENT METER circuit the signals return through jack J5 and terminals 10 and 11 of switch S5 to the balance resistor network, resistors R30 through R33, in the DELAY ADJUST METER circuit. This places the LOOP CURRENT METER in series with the odd-numbered channel loop. In the same position of switch S5, the signals from the EVEN CHANNEL jack are applied to switch S5 at terminal 5, and are passed through the switch by way of terminals 4, 7, and 8 to the balance resistor network. In the EVEN CHANNEL position of switch S5, the signals from the EVEN CHANNEL jack are connected through switch terminals 5 and 6 and INPUT jack J5, to the LOOP CURRENT METER circuit. From the LOOP CURRENT

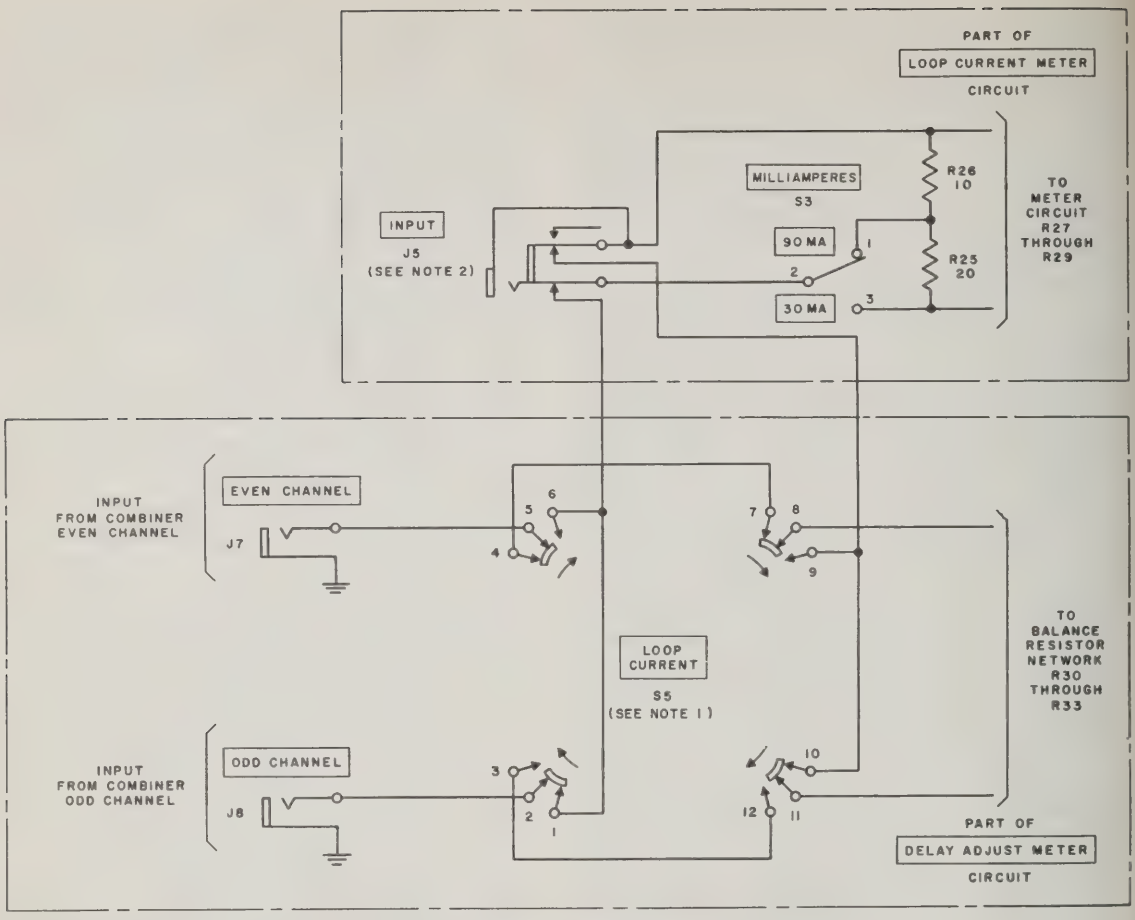



*Figure 156. DELAY METER and LOOP CURRENT METER circuits, action of LOOP CURRENT switch.*

METER circuit, the signals return through jack J5 and terminals 9 and 8 of switch S5 to the balance resistor network. This places the LOOP CURRENT METER in series with the even-numbered channel loop. In this same switch position, the odd-numbered channel signals are routed through switch terminals 2, 3, 12, and 11 to the balance resistor network.

(2) *Loop current balance.* For loop current balancing, DELAY-BALANCE switch S7 is placed in the BALANCE position, and the circuit takes on the configuration shown in the simplified schematic diagram (fig. 158). When the ODD CHANNEL and EVEN CHANNEL jacks of the DELAY ADJUST METER circuit are patched to the corresponding EQUIP jacks of the combiner, the loop keyers of the combiner and the balance network in the DELAY ADJUST METER circuit constitute a bridge network (fig. 157). The odd-numbered and even-numbered channel loop keyers of the combiner form two arms of the bridge with —130 volts applied to their common connection. The other two arms consist of one-half the balance network, resistors R30 and R32 in series, and the

second half of this network, resistors R31 and R33 in series. Ground is applied between the two halves of the balance network. When both loop keyers are closed (combiner IDLE-NORMAL switches are in the IDLE position), current (dc) flows through two similar paths. One path is from ground through resistors R32 and R30, and the even-numbered channel loop keyer to −130 volts. The second path is from ground through resistors R33 and R31, and the odd-numbered channel loop keyer to −130 volts. Since resistors R30 and R31 are equal, and resistors R32 and R33 are equal, no potential difference will exist between points G and F (fig. 158), if equal currents are flowing in both paths. Under this condition, no current flows through the meter circuit. If the currents in the two paths are unequal, a potential difference exists between G and F and current flows in the meter circuit, through resistors R40 and R42, causing meter M3 to deflect. Adjustment of either LOOP CURRENT ADJUST control in the combiner to values which return the meter to zero sets the odd-numbered channel loop current approximately equal to the even-numbered channel loop current. When the BALANCE SENSITIVITY switch S6 is momentarily closed, resistor R40 is shorted out of the circuit, increasing the sensitivity of the meter circuit. This permits the accurate balancing of the two loop currents which is necessary to prevent differences between them from introducing errors in delay adjustments ((3) below).

(3) *Delay adjustments.* When the DELAY ADJUST METER is used for making delay adjustments, the BALANCE-DELAY switch S7 is placed in the DELAY position, arranging the circuit as shown in the simplified schematic diagram of A, figure 159. In this arrangement, points F and G are connected through switching varistor CR1, and resistors R34 through R37, to an integrating network made up of resistors R41 and R42 and capacitors C12 and C13, and to meter M3. The polarization of the switching varistor CR1 is controlled by the signal voltages that appear at the EVEN CHANNEL and ODD CHANNEL jacks J7 and J8. These potentials are applied to these jacks from the corresponding combiner EQUIP jacks. When both combiner IDLE-NORMAL switches are in the NORMAL position, each loop keyer in the combiner is actuated by dotting signals from a single DOTTER at the distant transmitter. The potential at jacks J7 and J8 is zero with respect to ground when its associated keyer is open (spacing), and −70 volts when its associated keyer is closed (marking). The input signal at either jack has a wave shape like those at H and J of B, figure 159. The even-numbered channel signal passes through differentiating capacitor C10 to point K and the odd-numbered channel signal passes through differentiating capacitor C11 also to point K. The wave form at K represents the summation of waves J and H after differentiation by capacitors C10 and C11, and is symmetrical with respect to ground since the dc components of the signals are removed by the differentiating capacitors. This wave retains the same shape and time relationship for a given delay difference between channels. In the example shown in figure 159, wave J (even-numbered channel) is delayed with respect to wave H (odd-numbered channel) so that wave K crosses the zero axis in phase with wave H. If the time relationship of waves J and H is interchanged, wave K remains unaltered so that it crosses the axis in phase with wave J. Wave K reverses polarity in phase with the signal having the least delay. When the polarity at point K is negative with respect to ground, two equal currents flow through varistor switch CR1. One current takes the path from ground through resistors R32 and R34, diode B, and resistor R38 to point K. The second takes the path from ground through resistors R33 and R37, diode A and resistor R39 to point K. Since each path has equal resistance, equal currents flow through equal resistors R38 and R39, so that the potential drops across these resistors cancel with

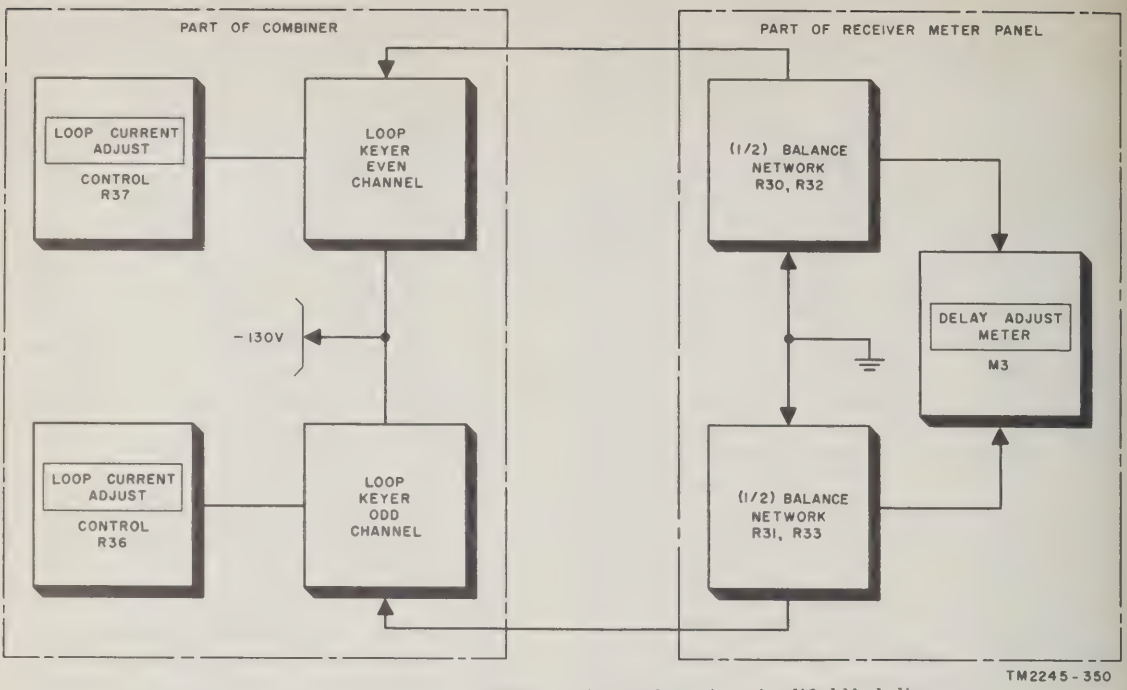



*Figure 157. DELAY ADJUST METER, bridge configuration, simplified block diagram.*

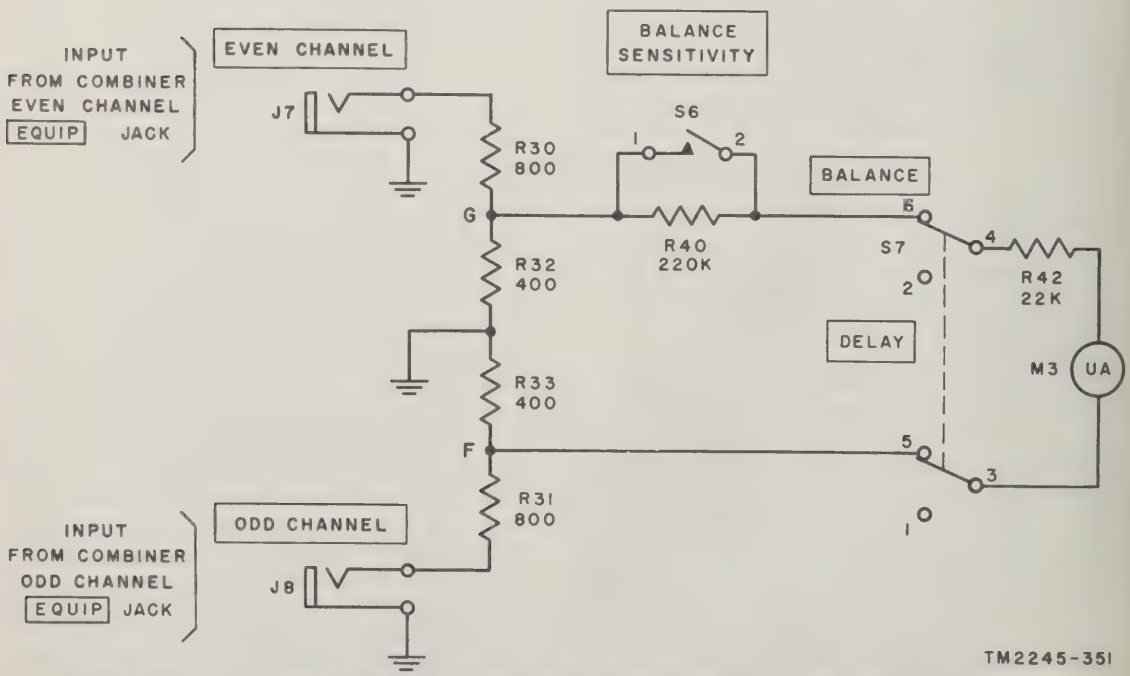



*Figure 158. DELAY ADJUST METER, configuration for balance adjustment, simplified schematic diagram.*

respect to the meter M3 circuit. Points F and G are now connected to the meter circuit through conducting diodes A and B, respectively. When the polarity at point K is positive with respect to ground two equal currents also flow through varistor switch CR1. One current takes the path from point K through resistor R38, diode D, and resistors R36 and R33 to ground. The second takes the path from point K through resistor R39, diode C, and resistors R35 and R32 to ground. The potentials developed across resistor R38 and R39 due to these currents also cancel with respect to the meter circuit. Conducting diodes C and D reverse the connections between points F and G and the meter circuit, with respect to the connections established by diodes A and B with point K negative with respect to ground. The input signal to the varistor switch is the potential difference existing between points F and G. When both keyers are closed or both keyers are open, no potential difference exists because of the balanced configuration of the circuit. Under these conditions there is no input signal to the diode switch and consequently no current through the meter circuit. When the odd keyer is open and the even keyer is closed, point F becomes positive with respect to point G. When the even keyer is open and the odd keyer is closed, point G becomes positive with respect to point F. When dotting signals are being received, the potential between points F and G varies as shown by wave shape E1, remaining zero except when the keyers are in opposite conditions because of difference in the delay of the two channels. The action of the varistor switch produces rectified pulses E2. During the intervals when the odd-numbered channel keyer is open and the even channel keyer closed, (B, fig. 159) wave K is also positive so that diodes C and D are conducting and diodes A and B are open. Since F is positive with respect to G, a signal current flows from F through resistor R36, diode D, resistors R38 and R39, diode C and resistor R35 to point G. The magnitude of this current is small compared with the switching current flowing as a result of the positive control voltage applied at point K. Consequently, it does not change the conducting condition of the switching varistor. The signal current flowing through resistors R38 and R39 causes the upper end of resistor R38 to become positive with respect to the lower end of resistor R39. A signal current now flows from the upper end of resistor R38 through resistors R41 and R42 and meter M3 to the lower end of resistor R39. This current causes the meter to deflect to the left. One dot interval later, the odd-numbered channel keyer is closed while the even-numbered channel loop is open. This reverses the polarity of the signal between points F and G, so that G is positive with respect to F. At this time the potential at K has also reversed from positive to negative so that diodes A and B are now conducting and diodes C and D are open. A current now flows from G through resistor R34, diode B, resistors R38 and R39, diode A, and resistor R37 to point F. The signal current flows through resistors R38 and R39 in the same direction as before and the deflection of the meter is still to the left. If the time relationship of the odd-numbered and even-numbered channels is reversed so that the odd-numbered channel is delayed with respect to the even-numbered channel, the polarity of wave E1 reverses while wave K remains unaltered. Under this condition the signal current flows through resistors R38 and R39 in the opposite direction, so that current flows from the lower end of resistor R39 through the meter circuit to the upper end of resistor R38 causing the meter to deflect to the right. Thus, when the even-numbered channel signal is delayed with respect to the odd-numbered channel signal, the meter will deflect to the left (toward the ODD CHANNEL marking on the panel) indicating that delay must be added to the odd-numbered channel. When the odd loop signal is delayed with respect to the even loop signal, the meter deflects to the right (toward the EVEN CHANNEL marking on the panel), indicating

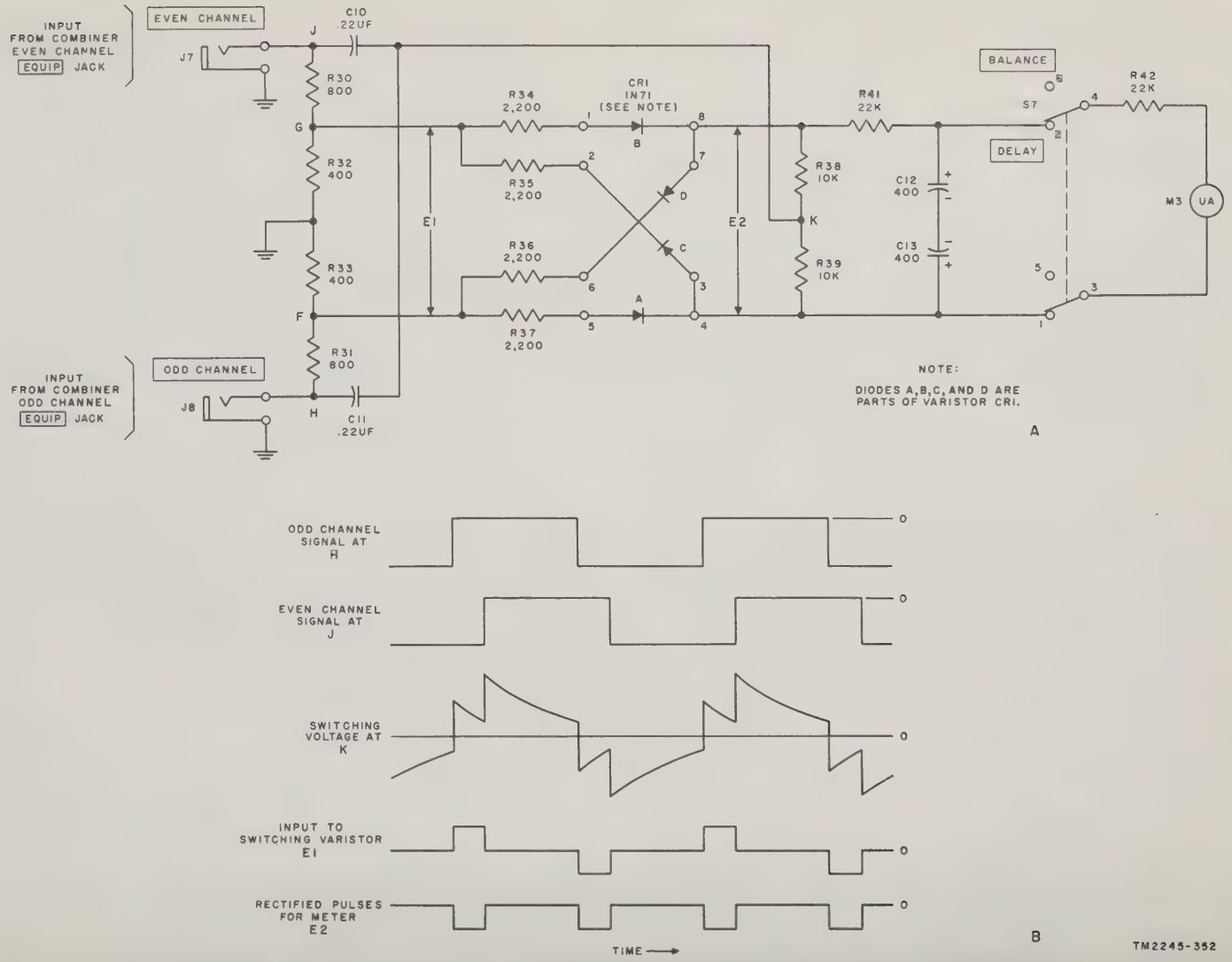



*Figure 159. DELAY ADJUST METER, configuration for delay adjustment, simplified schematic diagram.*

that delay must be added to the even-numbered channel. Delay adjustments are made by use of the DELAY ADJ controls in the receivers as described in paragraph 183. If the signals in both loops are exactly in phase, there is no time in which they are in the opposite condition of marking or spacing. As a result no potential difference appears between points F and G and, consequently, no input signal is applied to the varistor switch so that the meter reads zero, indicating correct delay equalization. Resistors R41 and R42 and capacitors C12 and C13 constitute an integrating circuit with a long time constant. This integrating circuit makes the meter reading proportional to the average of a large number of rectified pulses E2 so that the effect of random variations in the loop current reversals due to fading or noise in the radio path is effectively suppressed.

## 229. DIVERSITY ALIGNMENT PANEL, Block Diagram Analysis

(fig. 160)

The DIVERSITY ALIGNMENT PANEL provides a means of applying signals directly from the two channels of a transmitter of the AN/FGC–29 terminal to the corresponding diversity receivers for conducting testing and alignment procedures. Signals from the transmitter at the normal output level (−15 dbm) are raised to the normal input level (−8 dbm) for the receivers by amplifying circuits in the DIVERSITY ALIGNMENT PANEL. The two channels of the transmitter (always at different frequencies) pass through a COMMON ATTENUATOR and an amplifier, and feed four output circuits which are patched to the A and B paths of the corresponding receivers. The COMMON ATTENUATOR inserts 20 or 40 db of attenuation so that the receiver circuits may be tested at levels 20 or 40 db below normal input to simulate fading over the radio path. A separate BRANCHING NETWORK is also provided on the DIVERSITY ALIGNMENT PANEL.

*a. Diversity Alignment Circuit.* Signals from the odd-numbered channel of the transmitter enter the diversity alignment circuit at ODD NO. CHAN. jacks J1 and J2, and signals from the even-numbered channel enter at EVEN NO. CHAN. jacks J3 and J4. Both sets of signals are applied to COMMON ATTENUATOR switch S1. This switch selects combinations of attenuators AT1, AT2, and AT3, to insert 8 db, 28 db, or 48 db in the signal path. In the 0 position of switch S1, the signals are applied through attenuator AT3 (an 8-db pad) to input transformer T1. In the 20-db position the signals are applied through attenuator AT1 (a 20-db pad) and then through attenuator AT3. In the 40-db position, the signals are applied consecutively through attenuator AT1, attenuator AT2 (a 20-db pad), and attenuator AT3 to input transformer T1, From transformer T1 the signals enter first amplifier stage V1A. The amplified signals pass through second amplifier stage V1B to an interstage network composed of resistors R3 and R8 and capacitors C2, C3, and C4. This network attenuates frequencies above and below the signal band and couples the signals to third amplifier V2. The overall gain and output impedance of the amplifier stages is stabilized by voltage feedback from the output of tube V2 through the voltage feedback network, made up of resistor R17 and capacitor C5, to the input of first amplifier V1A. The signals from third amplifier V2 are passed by output transformer T2 to an impedance-matching resistor network having four outputs. The outputs from resistor branches R4 and R12 feed ODD NUMBERED CHANNEL RECEIVER A jacks J5 and J6, and RECEIVER B jacks J7 and J8. The outputs from resistor branches R13 and R16 feed EVEN-NUMBERED CHANNEL RECEIVER A jacks J9 and J10, and RECEIVER B jacks J11 and J12. ON-OFF switches S2 through S5 provide a means for removing signals from any combination of OUTPUT jacks. Both channel signals applied to the input of the diversity alignment circuit are present in the output of each jack pair, but only the desired signal is selected by the particular channel filter in the receiver.

*b. Power Circuit.* Input power at 115 volts ac, 50 or 60 cps, is applied to the circuit through POWER switch S6 which has ON and OFF positions. In the ON position power is applied through power transformer T3 to rectifier V3. Rectifier V3 operates into a filter circuit composed of inductor L1, and capacitors C6A and C6B, and supplies +180 volts dc for the plate circuits of tubes V1A, V1B, and V2. Heater voltage at 6.3 volts ac is supplied from power transformer T3 for the heaters of tubes V1, V2, and V3.

POWER INDICATOR I3 in the heater circuit glows as long as ac power is present in the circuit.

*c. BRANCHING NETWORK.* A separate BRANCHING NETWORK on the panel provides a means of obtaining two 600-ohm balanced output circuits from a single 600-ohm balanced input circuit when required. A signal applied at the IN jacks J14 and J15 is routed by the BRANCHING NETWORK, made up of resistors R25 through R30, to two outputs at the OUT 1 jacks J16 and J17 and OUT 2 jacks J18 and J19. The BRANCHING NETWORK is principally used to connect the output of the telegraph transmitter group to the A and B path inputs of the telegraph receiver group for local tests when multiplexers and demultiplexers are not available at the AN/FGC–29 terminal site.

*Figure 160. DIVERSITY ALIGNMENT PANEL, block diagram.*

(Contained in separate envelope)

## 230. DIVERSITY ALIGNMENT PANEL, Schematic Diagram Analysis

(fig. 161)

*a. Diversity Alignment Circuit.* Signals from the odd-numbered channel of the transmitter are applied to the INPUT of the diversity alignment circuit at ODD NO. CHAN. jacks J1 and J2 and from the even-numbered channel of the transmitter to the EVEN NO. CHAN. jacks J3 and J4. The INPUT jacks are connected in parallel so that signals from both inputs are applied to the COMMON ATTENUATOR switch S1 at terminal 1. In the 0 position of switch S1, the signals pass by way of switch terminals 1, 2, 6, and 5 to attenuator AT3, and 8-db pad, which sets the input signals at a level suitable for the amplifier circuits which follow. In the 20 position of switch S1, the signals are applied through terminals 1 and 3 to attenuator AT1, a 20-db pad, at terminal IN and pass through the attenuator to terminal OUT and then through switch contacts 7 and 5 to attenuator AT3. In the 40 position the signals pass from switch terminals 1, 4, and 3 to attenuator AT1 at terminal IN, and from terminal OUT through switch terminals 9 and 12 to attenuator AT2, a 20-db pad, at terminal IN. After passing through the pad, the signals are taken from terminal OUT and routed through the switch by way of terminals 8 and 5 to attenuator AT3. When attenuator AT1 is switched into the circuit, the signal level applied to the receivers is reduced 20 db below normal and when attenuator AT2 is also switched into the circuit the signal level is further reduced to 40 db below normal. The signals from terminal OUT of attenuator AT3 are applied to transformer T1 at terminal 1 with terminal 2 grounded. Transformer T1 has an impedance ratio of 600 ohms to 6,000 ohms to match the impedance of the attenuators to that of input resistor R5 of first amplifier stage V1A. The signals from the transformer secondary at terminals 4 and 3 are applied across resistor R5 to the grid of first amplifier V1A. Resistor R15 provides cathode-bias and resistor R1 provides plate load for the stage. Signals from the plate of V1A are applied to grid resistor R6 and the grid of second amplifier V1B by coupling capacitor C1. Resistor R7 is the cathode-biasing resistor and resistor R2 is the plate load resistor for the second amplifier stage. Signals from the plate of the second amplifier are fed through an interstage coupling network composed of capacitors C2, C3, and C4 and resistors R3 and R8 to the grids of third amplifier V2, a parallel-connected dual triode stage. The combination of resistor R8 and capacitor C4 in series connected across the signal circuit attenuates frequencies above the signal band. The network consisting of resistor R3 shunted by capacitor C3 attenuates frequencies below the signal band. Resistor R9 is the common grid resistor and resistor R10 the common cathode-biasing resistor for the stage. Negative voltage feedback is furnished from the plates of V2 through blocking capacitor C5 and resistor R17 to feedback resistor R14 in the grid circuit of first amplifier V1A. This negative feedback stabilizes the overall amplifier gain and output impedance. Plate load for third amplifier V2 is furnished by the primary of transformer T2. Signals from the secondary of transformer T2 are taken from terminal 6 with terminal 5 grounded, and applied to four outputs through resistors R4, R12, R13, and R16 which act, in conjunction with terminating resistor R11, as a branching network to supply the same signal levels to all four outputs. Resistor branches R4 and R12 feed ODD-NUMBERED CHANNEL RECEIVER A jacks J5 and J6 through switch S2, and RECEIVER B jacks J7 and J8 through switch S3. Resistor branches R13 and R16 feed EVEN-NUMBERED CHANNEL RECEIVER A jacks J9 and J10 through switch S4, and RECEIVER B jacks J11 and J12 through switch S5. Switches S2 through S5 have ON and OFF positions. In

the OFF position, each switch removes the signal from its associated A or B receiver and applies it to one of dummy load resistors R21 through R24.

*b. Power Circuit.* Power for the DIVERSITY ALIGNMENT PANEL circuit is supplied by a power circuit which accepts a 115 volts ac input at 50 or 60 cps, and delivers an output of +180 volts dc for the vacuum tube plate circuits and 6.3 volts ac for their heater circuits. The ac input enters at connector J13 and is applied across POWER switch S6, a double-pole, single-throw switch with ON and OFF positions. Power is supplied from switch S6 through fuses F1 and F2 to power transformer T3 at terminals 1 and 3 and terminals 2 and 4 of both primary windings connected in parallel. Fuses F1 and F2 protect the DIVERSITY ALIGNMENT PANEL from overload. BLOWN FUSE INDICATORS I 1 and I 2, bridged across fuses F1 and F2, respectively, glow when the corresponding fuse blows. Input for rectifier V3 is taken from terminals 7 and 9 of transformer T2 secondary. Rectifier V3 is used in a conventional half-wave rectifier circuit feeding the plate supply filter, which consists of inductor L1 and capacitor sections C6A and C6B. Resistor R18 is the load resistor. A positive voltage of 180 volts dc is supplied to the plate circuits of tubes V1A, V1B, and V2 from the high end of resistor R18. Heater voltage at 6.3 volts ac for tube heaters is taken from a separate winding of transformer T3 at terminals 5 and 6. POWER INDICATOR I 3 is bridged across the heater circuit and glows when ac power is present in this circuit.

*c. Branching Network.* The BRANCHING NETWORK is a balanced, 600-ohm, three-way pad which derives the output paths from a single input path with a 6-db loss between the input and either output. The impedance looking into any of the three arms of the pad is a constant 600 ohms when the other two arms are terminated in 600 ohms. The BRANCHING NETWORK consists of equal resistors R25 through R30. Signals applied to IN jacks J14 and J15 pass through resistors R25 and R28 and branch to OUT 1 jacks J16 and J17 through resistors R26 and R30. The signals from resistors R25 and R28 are also applied to OUT 2 jacks J18 and J19 through branching resistors R27 and R29.

*Figure 161. DIVERSITY ALIGNMENT PANEL, schematic diagram.*

(Contained in separate envelope)

# CHAPTER 5
# MAINTENANCE

## Section I. PREVENTIVE MAINTENANCE SERVICES

### 231. Definition of Preventive Maintenance

Preventive maintenance is work performed on equipment (usually when the equipment is not in use) to keep it in good working condition so that breakdowns and needless interruptions in service will be kept to a minimum. Preventive maintenance differs from troubleshooting and repair since its object is to prevent certain troubles from occurring.

### 232. General Preventive Maintenance Techniques

*a.* Use No. 0000 sandpaper to remove rust and corrosion.

*b.* Use a clean, dry, lint-free cloth or a dry brush for cleaning.

*c.* If necessary, moisten the cloth or brush with cleaning compound (liquid form, Federal Stock No. 7930–395–9542); then wipe the parts with a dry cloth.

*d.* If available, dry compressed air may be used at a line pressure not exceeding 60 pounds per square inch to remove dust from inaccessible places. Be careful, however, or mechanical damage from the air blast may result.

## Section II. LUBRICATION

### 233. Lubrication of Drawer Slides

The rollers of the drawer slides used with Telegraph Terminal AN/FGC–29 will require occasional lubrication. These rollers are accessible after removing the chassis from the slides (par. 58*b*). There are six rollers on the chassis (three on each side). There are four more rollers on the slides in the cabinet (two on each of the slides). Lubricate the shafts of the rollers semiannually, applying 2 or 3 drops of Oil, Lubricating, Preservative, Special (PL Special) to each shaft.

### 234. Cleaning and Lubrication of Controls and Air Filters

*a.* Clean LEVEL ADJUST controls of the LEVEL CONTROL & PLATE SUPPLY, multiplexers, demultiplexers, and audio frequency amplifiers, and the ATTENUATOR controls of the TRANSMITTER METER PANEL and RECEIVER METER PANEL semiannually. Coat them with a thin fi m of lubricant. The dust covers of these attenuators can be reached from the rear of the panel.

(1) To remove a cover, depress the release spring. At the same time, rotate the cover counterclockwise and lift it off.

(2) Clean and polish the contact studs and slip rings with a soft, dry, lint-free cloth.

(3) To remove darkened deposits of lubricant, moisten the cloth with denatured alcohol; then polish with a dry cloth.

(4) Lubricate the contact studs and sliprings by wiping them lightly with a clean cloth into which has been worked a small amount of petrolatum (technical) PET, Federal Spec. No. 14P1C.

(5) Grasp the front-panel knob and rotate the blades several times to distribute the lubricant. Do not leave excess lubricant on the edges of the rings or between the studs.

(6) Replace the cover carefully, making sure that the guide pins on the attenuator fit properly into the indentations on the cover. Rotate the cover clockwise until the release spring locks in place.

*b.* Clean and oil the air intake filters mounted in the rear door of each cabinet at monthly intervals.

(1) To remove the air filter, first release the

four camlock fasteners that hold the air intake funnel in place. Open the funnel and remove the filter.

(2) Wash the filter with cleaning compound to remove oil and accumulated dirt. Allow the filter to dry thoroughly.

(3) Lubricate the filter by dipping it in a light lubricating oil such as low-viscosity petroleum lubricating oil, Federal Specification VV–L–820. Suspend the filter and permit excess oil to drain.

(4) Clean accumulated dirt from the air intake louvers in the bottom of the rear door of each cabinet.

(5) Replace the air filter and lock the air intake funnel in place with the four camlock fasteners.

### 235. Lubrication of Blower Motors

The blower motors used in each of the six cabinets of Telegraph Terminal AN/FGC–29 will require lubrication every 2 months when in continuous operation. Lubrication should also be applied after prolonged periods of storage or idleness.

*a.* The blower motors are located in the bottom rear of each cabinet and are accessible after opening the rear door of the cabinet.

*b.* There are two lubrication points on each motor, located at each end of the housing above the shaft bearings.

*c.* Apply a few drops of a refined, low-viscosity petroleum lubricating oil, Federal Specifications VV–L–820, into each of the oil holes. Be careful not to use too much oil as damage to the motor may result.

## Section III. WEATHERPROOFING

### 236. Moistureproofing and Fungiproofing

A moistureproofing and fungiproofing protective coating is applied to Telegraph Terminal AN/FGC–29 at the time of manufacture. Further applications of this protective coating are necessary only when parts are repaired or replaced.

### 237. Rustproofing and Painting

*a.* When the finish on exposed metal surfaces has been scarred or damaged, rust and corrosion can be prevented by touching up bared surfaces. Use No. 00 or No. 000 sandpaper to clean the surface down to the bare metal; obtain a bright, smooth finish.

***Caution:*** Do not use steel wool. Minute particles frequently enter the case and cause harmful internal shorting or grounding of circuits.

*b.* When a touchup job is necessary, apply paint with a small brush. Remove rust from the surface to be painted by cleaning corroded metal with cleaning compound. In severe cases it may be necessary to use cleaning compound to soften the rust and to use sandpaper to complete the preparation for painting.

## Section IV. TROUBLESHOOTING

***Warning:*** When shooting trouble or making repairs in this equipment, be careful to avoid contact with exposed high-voltage connections. Potentials as high as 720 volts are present. Use insulated test probes when making the required voltage measurements. Always disconnect the power cord from the equipment before touching any of the internal parts.

### 238. General

Troubleshooting may be performed while the equipment is operating as part of a system or, if necessary, after the equipment (or parts of it) has been removed from service. When trouble occurs, certain observations and measurements can be made which will help in determining whether the local equipment is at fault or if the trouble exists elsewhere in the system. The following paragraph describes the steps to be followed in a systematic procedure which will help the repairman to isolate the cause of the trouble and correct the fault.

### 239. Troubleshooting Procedure

To be effective, troubleshooting must be systematic. It will be necessary to perform a sequence of observations and measurements so that the trouble is traced first to an equipment unit, then to a portion of the unit, and finally to a defective part. This sequence of procedures is referred to as the sectionalization, operational test, localization, and isolation of trouble.

*a. Sectionalization.* The first aim of troubleshooting is to sectionalize the trouble to a defective equipment unit (component). The sectionalizing tests described in paragraphs 251 through 257 aid the repairman to obtain as many symptoms of the trouble as possible without removing the equipment from service.

*b. Operational Test.* The next step is to make an operational test with the suspected unit disconnected from the system and the power on. Disconnect *only* the input and output signals. The operational test serves as a check on the sectionalizing test. It indicates definitely whether or not the unit is functioning properly. When these tests indicate a particular component is faulty, the procedures described in (1) and (2) below will often lead the repairman directly to the source of trouble; if not, the localization and isolation tests (*c* and *d* below) will aid in locating the defective part or circuit.

(1) *Visual inspection.* The purpose of visual inspection (par. 242) is to locate any visible trouble. Through this inspection alone, the repairman can frequently discover the trouble or determine its approximate location. This inspection is also valuable in preventing future trouble.

(2) *Pluck-out parts.* Defective tubes and other pluck-out parts will be responsible for many cases of trouole. Remove and test all pluck-out parts suspected of being faulty (par. 243). Replace each defective part with an identical part known to be good.

*c. Localization.* When the general nature of the trouble has been determined, make additional tests to localize the trouble to a portion of the faulty unit. The trouble localization tests will check the performance of each subassembly involved.

*d. Isolation.* After the trouble has been localized, it is necessary to isolate the cause. The trouble isolation tests will check the performance of each stage of the circuit until a point is reached where an abnormal indication is obtained. Measurements on that portion of the circuit will then isolate the defective part.

## 240. Troubleshooting Data

The charts in *a* through *s* below contain references to illustrations that will help the repairman troubleshoot telegraph terminal AN/FGC–29.

*a. Transmitting Terminal.*

| Fig. No. | Description |
|---|---|
| 136 | Transmitting terminal, arranged for 6-kc operation, schematic diagram. |
| 137 | Transmitting terminal, arranged for 3-kc operation, schematic diagram. |
| 141 | Transmitting terminal, remote control switching, schematic diagram. |
| 260 | Transmitting terminal, ac power distribution, schematic diagram. |
| 145 | Transmitting terminal, B-plus voltage distribution, schematic diagram. |
| 147 | Transmitting terminal, loop battery distribution, schematic diagram. |
| 162 | Cabinet 1, rear view. |
| 163 | Cabinet 2, rear view. |
| 33 | Transmitting terminal, intercabinet cording diagram. |
| 35 | Telegraph Terminal AN/FGC–29, primary power and ground connections. |
| 36 | Transmitting terminal, external signal connections. |
| 248 | Transmitting terminal, controls and test points, block diagram. |
| 262 | Cabinet 1, wiring diagram. |
| 263 | Cabinet 2, wiring diagram. |
| 299 | MIL STD capacitor color code chart. |
| 300 | MIL STD resistor color code chart. |

*b. Receiving Terminal.*

| Fig. No. | Description |
|---|---|
| 142 | Receiving terminal, remote control switching, schematic diagram. |
| 261 | Receiving terminal, ac power distribution, schematic diagram. |
| 146 | Receiving terminal, B-plus voltage distribution, schematic diagram. |
| 148 | Receiving terminal, loop battery distribution, schematic diagram. |
| 164 | Cabinet 3, rear view. |
| 165 | Cabinet 4, rear view. |
| 166 | Cabinet 5, rear view. |
| 167 | Cabinet 6, rear view. |
| 34 | Receiving terminal, intercabinet cording diagram. |
| 35 | Telegraph Terminal AN/FGC–29, primary power and ground connections. |
| 37 | Receiving terminal, external signal connections. |
| 252 | Receiving terminal arranged for 6-kc operation, schematic diagram. |
| 253 | Receiving terminal arranged for 3-kc operation, schematic diagram. |
| 249 | Receiving terminal, controls and test points, block diagram. |
| 264 | Cabinet 3, wiring diagram. |
| 265 | Cabinet 4, wiring diagram. |
| 266 | Cabinet 5, wiring diagram. |
| 267 | Cabinet 6, wiring diagram. |
| 299 | MIL STD capacitor color code chart. |
| 300 | MIL STD resistor color code chart. |

### c. *Transmitter.*

| Fig. No. | Description |
|---|---|
| 254 | Transmitter, schematic diagram. |
| 81 | Transmitter, keyer, schematic diagram. |
| 82 | Transmitter, oscillator tuner, schematic diagram. |
| 84 | Transmitter, bias supply, schematic diagram. |
| 85 | Transmitter, tuned network, schematic diagram. |
| 86 | Transmitter filter, schematic diagram. |
| 171 | Transmitter, top view. |
| 172 | Transmitter, bottom view. |
| 173 | Keyer, top view. |
| 174 | Keyer, bottom view. |
| 175 | Keyer, rear of terminal board TB1. |
| 176 | Bias supply, top view. |
| 177 | Bias supply, bottom view. |
| 178 | Oscillator tuner, bottom view. |
| 179 | Oscillator tuner, bottom view with terminal board TB4 removed and rotated. |
| 180 | Transmitter and receiver filters, and mod filter 2, test arrangement. |
| 268 | Transmitter, wiring diagram. |
| 269 | Transmitter, keyer, wiring diagram. |
| 270 | Transmitter, oscillator tuner, wiring diagram. |
| 271 | Transmitter, bias supply, wiring diagram. |

### d. *SUBGROUP MODULATOR.*

| Fig. No. | Description |
|---|---|
| 90 | SUBGROUP MODULATOR, schematic diagram. |
| 92 | SUBGROUP MODULATOR, converter, schematic diagram. |
| 93 | SUBGROUP MODULATOR, mod filter 1, schematic diagram. |
| 94 | SUBGROUP MODULATOR, mod filter 2, schematic diagram. |
| 96 | SUBGROUP MODULATOR, carrier supply, schematic diagram. |
| 100 | SUBGROUP MODULATOR, modulator, schematic diagram. |
| 101 | SUBGROUP MODULATOR, output coupler, schematic diagram. |
| 102 | SUBGROUP MODULATOR, plate supply, schematic diagram. |
| 180 | Transmitter and receiver filters, and mod filter 2, test arrangement. |
| 193 | Mod filter 1 and demod filter 1, test arrangement. |
| 181 | SUBGROUP MODULATOR, top view. |
| 182 | SUBGROUP MODULATOR, bottom view. |
| 183 | Converter, top view. |
| 184 | Converter, bottom view from right side. |
| 185 | Converter, bottom view from left side. |
| 188 | Carrier supply, top view. |
| 189 | Carrier supply, bottom view from right side. |
| 190 | Carrier supply, bottom view from left side. |
| 186 | Modulator, top view. |
| 187 | Modulator, bottom view. |
| 87 | SUBGROUP MODULATOR, frequency translation chart. |
| 194 | Output coupler, top view. |
| 195 | Output coupler, bottom view. |
| 191 | Plate supply, top view. |
| 192 | Plate supply, bottom view. |
| 272 | SUBGROUP MODULATOR, wiring diagram. |
| 273 | SUBGROUP MODULATOR, converter, wiring diagram. |
| 274 | Modulator, wiring diagram. |
| 275 | Carrier supply, wiring diagram. |
| 276 | Plate supply, wiring diagram. |
| 277 | Output coupler, wiring diagram. |

### e. *LEVEL CONTROL & PLATE SUPPLY.*

| Fig. No. | Description |
|---|---|
| 104 | LEVEL CONTROL & PLATE SUPPLY, schematic diagram. |
| 106 | LEVEL CONTROL & PLATE SUPPLY, line amplifier schematic diagram. |
| 102 | SUBGROUP MODULATOR, plate supply, schematic diagram. |
| 196 | LEVEL CONTROL & PLATE SUPPLY, top view. |
| 197 | LEVEL CONTROL & PLATE SUPPLY, bottom view. |
| 198 | Line amplifier, top view. |
| 199 | Line amplifier, bottom view from right side. |
| 200 | Line amplifier, bottom view from left side. |
| 191 | Plate supply, top view. |
| 192 | Plate supply, bottom view. |
| 278 | LEVEL CONTROL & PLATE SUPPLY, wiring diagram. |
| 279 | Line amplifier, wiring diagram. |
| 276 | Plate supply, wiring diagram. |

### f. *3KC SEND BAND TEST PANEL*

| Fig. No. | Description |
|---|---|
| 139 | 3KC SEND BAND TEST PANEL, schematic diagram. |
| 201 | 3KC SEND BAND TEST PANEL, rear view. |
| 289 | 3KC SEND BAND TEST PANEL, wiring diagram. |

### g. *Transformer Assembly TF–206/FG.*

| Fig. No. | Description |
|---|---|
| 138 | Transformer Assembly TF–206/FG, schematic diagram. |
| 202 | Transformer Assembly TF–206/FG, front view, cover removed. |
| 288 | Transformer Assembly TF–206/FG, wiring diagram. |

### h. *3KC RECEIVE BAND TEST PANEL.*

| Fig. No. | Description |
|---|---|
| 140 | 3KC RECEIVE BAND TEST PANEL, schematic diagram. |
| 204 | 3KC RECEIVE BAND TEST PANEL, rear view. |
| 290 | 3KC RECEIVE BAND TEST PANEL, wiring diagram. |

### i. *SUBGROUP DEMODULATOR.*

| Fig. No. | Description |
|---|---|
| 107 | SUBGROUP DEMODULATOR, frequency translation chart. |
| 109 | SUBGROUP DEMODULATOR, schematic diagram. |
| 111 | SUBGROUP DEMODULATOR, band amplifier, schematic diagram. |
| 112 | SUBGROUP DEMODULATOR, demod filter 1, schematic diagram. |
| 113 | SUBGROUP DEMODULATOR, input network, schematic diagram. |
| 96 | SUBGROUP MODULATOR, carrier supply, schematic diagram. |
| 102 | SUBGROUP MODULATOR, plate supply, schematic diagram. |
| 205 | SUBGROUP DEMODULATOR, top view. |
| 206 | SUBGROUP DEMODULATOR, bottom view. |
| 207 | Band amplifier, top view. |
| 208 | Band amplifier, bottom view from right side. |
| 186 | Modulator, top view. |
| 187 | Modulator, bottom view. |
| 188 | Carrier supply, top view. |
| 189 | Carrier supply, bottom view from right side. |
| 190 | Carrier supply, bottom view from left side. |
| 191 | Plate supply, top view. |
| 192 | Plate supply, bottom view. |
| 193 | Mod filter 1 and demod filter 1, test arrangement. |
| 280 | SUBGROUP DEMODULATOR, wiring diagram. |
| 281 | SUBGROUP DEMODULATOR, band amplifier, wiring diagram. |
| 274 | Modulator, wiring diagram. |
| 275 | Carrier supply, wiring diagram. |
| 276 | Plate supply, wiring diagram. |

### j. *Receiver.*

| Fig. No. | Description |
|---|---|
| 255 | Receiver, schematic diagram. |
| 115 | Receiver, delay amplifier, schematic diagram. |
| 122 | Receiver, AGC amplifier, schematic diagram. |
| 123 | Receiver filter, schematic diagram. |
| 102 | SUBGROUP MODULATOR, plate supply, schematic diagram. |
| 209 | Receiver, top view. |
| 210 | Receiver, bottom view. |
| 211 | Delay amplifier, top view. |
| 212 | Delay amplifier, bottom view. |
| 213 | Delay amplifier, bottom view, terminal board TB6 removed and rotated. |
| 214 | AGC amplifier, top view. |
| 215 | AGC amplifier, bottom view. |
| 216 | AGC amplifier, bottom view, terminal boards TB1, TB2, and TB3 removed and rotated. |
| 191 | Plate supply, top view. |
| 192 | Plate supply, bottom view. |
| 217 | AGC amplifier, bottom view, terminal board TB3 removed and rotated. |
| 218 | Delay tuner, test arrangement. |
| 180 | Transmitter and receiver filters and mod filter 2, test arrangement. |
| 282 | Receiver, wiring diagram. |
| 283 | AGC amplifier, wiring diagram. |
| 284 | Delay amplifier, wiring diagram. |
| 276 | Plate supply, wiring diagram. |

### k. *Combiner.*

| Fig. No. | Description |
|---|---|
| 256 | Combiner, schematic diagram. |
| 126 | Combiner, adder, schematic diagram. |
| 127 | Combiner, diversity switching circuits, two-channel diversity, simplified schematic diagram. |
| 131 | Combiner, transformer reactor assembly Z3, schematic diagram. |
| 132 | Combiner, discriminator, schematic diagram. |
| 219 | Combiner, top view. |
| 220 | Combiner, bottom view. |
| 221 | Adder, top view. |
| 222 | Adder, botom view. |
| 223 | Adder, bottom view, terminal boards TB2 and TB3 removed and rotated. |
| 224 | Discriminator, test arrangement. |
| 225 | Transformer reactor assembly, top view. |
| 226 | Transformer reactor assembly, bottom view. |
| 285 | Combiner, wiring diagram. |
| 287 | Adder, wiring diagram. |
| 286 | Combiner, transformer-reactor assembly, wiring diagram. |

## *l. AC POWER SWITCHING PANEL.*

| Fig. No. | Description |
|---|---|
| 260 | Transmitting terminal, ac power distribution, schematic diagram. |
| 261 | Receiving terminal, ac power distribution, schematic diagram. |
| 227 | AC POWER SWITCHING PANEL, rear view. |
| 291 | AC POWER SWITCHING PANEL, wiring diagram. |

## *m. Voltage Regulator.*

| Fig. No. | Description |
|---|---|
| 144 | Voltage regulator, schematic diagram. |
| 168 | Voltage regulator in position. |
| 228 | Voltage regulator, front view. |
| 229 | Voltage regulator, bottom view. |
| 230 | Voltage regulator, terminal boards TB2 and TB3. |
| 292 | Voltage regulator, wiring diagram. |

## *n. LOOP BATTERY PANEL.*

| Fig. No. | Description |
|---|---|
| 147 | Transmitting terminal, loop battery distribution, schematic diagram. |
| 148 | Receiving terminal, loop battery distribution, schematic diagram. |
| 149 | LOOP BATTERY PANEL, schematic diagram. |
| 231 | LOOP BATTERY PANEL, rear view from above. |
| 293 | LOOP BATTERY PANEL, wiring diagram. |

## *o. Loop Battery Supply.*

| Fig. No. | Description |
|---|---|
| 150 | Loop battery supply, schematic diagram. |
| 170 | Loop battery supplies in position. |
| 232 | Loop battery supply, front view. |
| 233 | Loop battery supply, bottom view. |
| 294 | Loop battery supply, wiring diagram. |

## *p. TRANSMITTER METER PANEL.*

| Fig. No. | Description |
|---|---|
| 153 | TRANSMITTER METER PANEL, schematic diagram. |
| 234 | TRANSMITTER METER PANEL, top view. |
| 235 | TRANSMITTER METER PANEL, bottom view. |
| 236 | TRANSMITTER METER PANEL, terminal board TB1. |
| 237 | TRANSMITTER METER PANEL, terminal board TB2. |
| 295 | TRANSMITTER METER PANEL, wiring diagram. |

## *q. RECEIVER METER PANEL.*

| Fig. No. | Description |
|---|---|
| 155 | RECEIVER METER PANEL, schematic diagram. |
| 156 | DELAY METER and LOOP CURRENT METER circuits, action of LOOP CURRENT switch. |
| 238 | RECEIVER METER PANEL, top view. |
| 239 | RECEIVER METER PANEL, bottom view. |
| 240 | RECEIVER METER PANEL, terminal boards TB1 and TB2. |
| 296 | RECEIVER METER PANEL, wiring diagram. |

## *r. DIVERSITY ALIGNMENT PANEL.*

| Fig. No. | Description |
|---|---|
| 161 | DIVERSITY ALIGNMENT PANEL, schematic diagram. |
| 241 | DIVERSITY ALIGNMENT PANEL, top view. |
| 242 | DIVERSITY ALIGNMENT PANEL, bottom view. |
| 243 | DIVERSITY ALIGNMENT PANEL, terminal board TB1. |
| 297 | DIVERSITY ALIGNMENT PANEL, wiring diagram. |

## *s. Miscellaneous Units.*

| Fig. No. | Description |
|---|---|
| 257 | Multiplexer TD–97/FGT–2, schematic diagram. |
| 258 | Demultiplexer TD–98/FGR–3, schematic diagram. |
| 259 | Audio Frequency Amplifier AM–911/FG, schematic diagram. |
| 244 | Power panel, front and rear views. |
| 169 | Step-up power transformer. |
| 245 | DUMMY CIRCUIT PANEL, rear view. |
| 151 | RELAY PANEL, schematic diagram. |
| 246 | RELAY PANEL, front view. |
| 247 | RELAY PANEL, rear views. |
| 298 | RELAY PANEL, wiring diagram. |

## 241. Tools and Test Equipment Required

| Tool or test equipment | Technical manual |
|---|---|
| Tool Equipment TE–123 | TM 11–5527 |
| Multimeter TS–352/U | |
| Electron Tube Test Set TV–7/U | TM 11–5083 |
| Test Set TS–140/PCM, consisting of Signal Generator SG–15/PCM and Decibel Meter ME–22/PCM. | TM 11–2096 |
| Electronic Multimeter ME–6A/U | |
| Frequency Meter FR–67/U or Frequency Counter AN/USM–26 | TM 11–2698 |
| Volume Indicator ID–220A/FGT or ID–220B/FGT.* | |

*Required only when Multiplexer TD–97/FRT–2, Demultiplexer TD–98/FGR–3, and Audio Frequency Amplifier AM–911/FG are used at a location remote from that of Telegraph Terminal AN/FGC–29.

## 242. Visual Inspection

When the equipment fails to operate and the cause is not immediately apparent, check as many of the items listed in *a* and *b* below as is practicable before starting a systematic check of the equipment. Do not disassemble a component without some knowledge of the operational symptoms. If possible, obtain information regarding performance at the time trouble occurred.

*a. General.* Failure of the equipment to function properly often may be caused by one or more of the following faults:

(1) Power failure. Check main power units, AC POWER SWITCHING PANEL, loop battery supplies, ac voltage regulators, and primary power source.
(2) Blown fuses.
(3) Worn, broken, or disconnected cords or connectors.
(4) Wires or parts broken because of excessive strain or vibration.
(5) Defective tubes, crystals, or varistors.
(6) Defective switches, jacks, or level controls.
(7) Improperly seated pluck-out parts.
(8) Improperly connected cables or wiring.

*b. Controls.* Incorrect operation may be caused by the improper setting of one or more of the front-panel or internal controls. A complete check of the controls requires a knowledge of the correct setting for each control under normal operating conditions. If a record of the control settings is maintained, this will serve as a useful check list in locating any improper settings. If such a record is not available, refer to chapter 3 in this manual and in the manual covering the multiplexer, demultiplexer, and audio frequency amplifier. These settings, which apply when all 16 channels are in use, may have to be modified when the full number of channels are not being used (ch. 3). The normal settings of the multiplexer, demultiplexer, and LEVEL CONTROL & PLATE SUPPLY controls will be within 2 db of the values given in (1) through (4) below; the audio frequency amplifier controls are set as indicated below.

(1) *Multiplexer TD–97/FGT–2.* OUTPUT LEVEL ADJUST control in position 26.
(2) *Demultiplexer TD–98/FGR–3.*
  (*a*) INPUT LEVEL ADJUST control in position 50.
  (*b*) OUTPUT LEVEL ADJUST control in position indicated below:
    *1.* Telegraph service, position 41.
    *2.* Telephone service, position 36.
    *3.* Facsimile service, position 31.
(3) *Audio Frequency Amplifier AM–911/FG.*
  (*a*) LEVEL ADJUST control between positions 20 and 50, depending on operating conditions.
  (*b*) Equalizer switch in NONLOADED CABLE, LOADED CABLE, or EQUAL OUT position, corresponding to the requirement of the line facility.
  (*c*) The equalizer controls must not be disturbed after the equalizer has been adjusted for a line facility. If a front-panel cover is not in place, investigate the reason for removal and check the possibility that control settings have been disturbed.
(4) *LEVEL CONTROL & PLATE SUPPLY.* LEVEL ADJUST control in the position indicated in (*a*) and (*b*) below:
  (*a*) Space diversity, position 35.
  (*b*) Frequency diversity, position 41.

## 243. Removal and Test of Pluck-Out Parts

*a. Miniature Tubes.* All tubes are accessible from the top of the drawer-type chassis, and from the rear of the panel-mounted auxiliary components.

(1) Remove the tube shield by pressing the shield downward and rotating it counterclockwise until it releases.
(2) Remove the tube with a straight upward pull, using a tube puller if available. If a tube does not release easily, rock it

gently from side to side while maintaining an upward pull.

(3) Check the tube with a tube tester, such as Electron Tube Test Set TV–7/U. If the tube pins are bent, use one of the pin straighteners on the TRANSMITTER METER PANEL or DIVERSITY ALIGNMENT PANEL.

(4) Replace a defective tube with a spare tube known to be good. Be sure that the tube corresponds to the label adjacent to the socket or is an interchangeable type listed in *c* below.

(5) See that the tube is seated properly in its socket before restoring the tube shield.

*b. Large Tubes.* The larger-sized tubes are located in the loop battery supplies and the ac voltage regulators and are accessible after removal of the cover panels in front of those units.

(1) To remove the tube retainer, grasp the opposite ends of retainer spring between the thumb and forefinger. Then pull straight up until the retainer is released from the mounting studs.

(2) Lift the tube out of the socket.

(3) Check the tube with a tube tester, such as Electron Tube Test Set TV–7/U. Inspect the tube pins for dirt or corrosion. If necessary, clean the prongs with No. 0000 sandpaper.

(4) Replace each defective tube with a spare tube known to be good. Be sure that the tube type corresponds to the label adjacent to the socket, or is an interchangeable type listed in *c* below.

(5) To restore the tube retainer, place it on the mounting studs with the spring side up. Then press straight down on the center of the retainer until it presses firmly against the top of the tube.

*c. Interchangeable Tubes.* Refer to the chart below. For all applications the older type tube listed in the first column can be used interchangeable with the corresponding preferred type tube listed in the second column. The older types should be used until stocks are exhausted.

| Older type tube | Application | Preferred type tube |
|---|---|---|
| 2D21W | All applications | 5727/2D21W. |
| 5Y3GT | All applications | 5Y3WGTA. |
| 6AQ5W | All applications | 6005/6AQ5W. |
| 6AU6W | All applications | 6AU6WA. |
| 6X4W | All applications | 6X4W. |
| 5726 | All applications | 5726/6AL5W. |
| 5751 | All applications | 5751. |
| 5814 | All applications | 5814A. |
| 2AS15 | All applications | None. |
| 3B22 | All applications | None. |
| 6CL6 | All applications | None. |
| 807 | All applications | None. |

*d. Crystals.* The 25.16 kc and 19.38 kc crystals are easily accessible from the top of the multiplexer, demultiplexer, SUBGROUP MODULATOR, and SUBGROUP DEMODULATOR.

(1) To remove the crystal retainer, grasp the opposite ends of the retainer spring between the thumb and forefinger. Then pull straight up until the retainer is released from the mounting studs.

(2) Lift the crystal out of the socket. Handle crystals carefully.

(3) If the crystal is suspected of being defective, replace it with a spare crystal known to be good. Use only a type CR–50/U crystal of the proper frequency.

(4) To restore the crystal retainer, place it on the mounting studs with the spring side up. Then push straight down on the center of the retainer until it presses firmly against the top of the crystal.

*e. Varistors.* The varistors are easily accessible from the top of the multiplexer, demultiplexer, SUBGROUP MODULATOR, SUBGROUP DEMODULATOR, the front panel of the receivers, and from the rear of the RECEIVER METER PANEL.

(1) To remove a varistor, grasp it firmly and pull straight up. If the varistor does not release easily, rock it gently from side to side while maintaining an upward pull.

(2) Inspect the varistor prongs for dirt or corrosion. If necessary, clean the prongs with No. 0000 sandpaper.

(3) If the varistor is suspected of being defective, replace it with a spare varistor of the same type known to be good. Use only a type 1N71 varistor for all units except receivers which require a 1N435 type.

*f. Fuses.* The fuses are located on the front panels of most units, the only exceptions being the

main power fuses located in the rear of cabinets 1, 3, and 5; the blower motor fuses located in the rear of each cabinet; and a fuse in the control circuit of each voltage regulator accessible behind the front cover panel at the bottom of cabinets 2, 4, and 6.

(1) To remove a fuse, press down on the fuse-holder cap and turn it counterclockwise as indicated by the arrow on the cap. Pull out the fuse-holder cap and the fuse. To remove a fuse-holder cap on the AC POWER SWITCHING PANEL, merely turn the cap in the direction indicated.

(2) If the fuse is blown, replace it with a spare fuse of the same type and rating.

*g. Indicator Lamps.* The BLOWN FUSE INDICATORS are located just above or adjacent to the fuse with which each is associated, except for indicators associated with the blower motor fuses. These appear on the front cover panel at the bottom of each cabinet.

(1) To test an indicator lamp, remove the fuse associated with it. The lamp should light.

(2) To remove an indicator lamp, unscrew the lamp cap. Press the lamp in, and rotate it counterclockwise; then withdraw the lamp from the socket.

(3) If the indicator lamp is defective, replace it with spare. Use only a type NE51 neon indicator lamp.

## 244. General Precautions

Careless replacement of parts often makes new faults inevitable. Note the following points:

*a.* Before a part is soldered, note the position of the leads. If the part has a number of connections, tag each of the leads before unsoldering any of them.

*b.* When removing a defective part, be careful not to damage leads or other parts by pulling or pushing them out of the way.

*c.* Whenever replacing a part, install the new part in the same position as the original. Use an exact duplicate whenever possible.

*d.* If wiring must be replaced, use leads of the same length and run the leads in the same manner as the original wiring. Make connections to the same terminals used in the original wiring, even where there are alternatives which appear electrically equivalent.

*e.* Make well-soldered connections, using no more solder than is necessary. A carelessly soldered connection may create a new fault. A poorly soldered joint is one of the most difficult faults to find.

*f.* Do not allow drops of solder to fall into the unit. Do not allow a soldering iron to come into contact with insulation or parts that might be injured by excessive heat.

*g.* Do not disturb the setting of any LEVEL ADJUST control of Multiplexer TD–97/FGT–2, Demultiplexer TD–98/FGR–3, Audio Frequency Amplifier AM–911/FG, or LEVEL CONTROL and PLATE SUPPLY or of any DELAY ADJ control of the receivers without first noting its normal position. Restore the control to its proper setting before returning the equipment to service.

*h.* Do not disturb the setting of the equalizer controls (variable resistors R51 through R56) of Audio Frequency Amplifier AM–911/FG unnecessarily, as this will alter the amplifier lineup. If equalizer switch S2 or S3 are operated, return them to their original positions.

*i.* Do not disturb the strapping on terminal board TB9 of Multiplexer TD–97/FGT–2 or terminal board TB3 of Audio Frequency Amplifier AM–911/FG without first making a record of the correct wiring. Restore the proper strapping before returning the equipment to service.

*j.* Do not disturb the setting of any uncalibrated control without redetermining its proper setting before returning the equipment to service. If any switches are operated, return them to their original positions.

## 245. Instructions for Gaining Access to Difficult-to-Reach Parts and Circuits

Certain parts and circuits in the terminal are difficult to reach for repair or replacement. When shooting trouble on a particular unit, refer to the illustrations in this chapter that locate and identify the parts of the unit being checked. Determine the exact location of the part before attempting to gain access to it, and refer to *a* through *g* below for the appropriate instructions.

*a. Access to Parts in Transmitters, Combiners and Receivers.* The only parts in the transmitters, combiners, and receivers that are difficult to reach are located under the horizontally mounted terminal boards in the underside of the chassis. To move a terminal board out of the way, remove the screws that fasten the board to its support posts. There is enough slack in the wiring to permit the terminal board to be swung to one side. Once this is done, the parts on the other side of the

terminal board, as well as on the chassis beneath the board, become accessible. Be careful not to damage the wiring or connections when moving the terminal board out of place.

*b. Access to Parts in TRANSMITTER METER PANEL, RECEIVER METER PANEL, and DIVERSITY ALIGNMENT PANEL.* Parts located in components not mounted on drawer slides are not readily accessible. The TRANSMITTER METER PANEL, RECEIVER METER PANEL, and DIVERSITY ALIGNMENT PANEL must be removed from the cabinet for maintenance. These components are supported solely by four mounting screws through their front panels which secure the component to the cabinet. To remove one of these components, disconnect the power cord at the rear of the component, loosen the mounting screws on the front panel, and withdraw the component from the front of the cabinet.

***Caution:*** To prevent dropping and damaging a component when removing it from its cabinet, make sure that it is adequately supported.

*c. Access to Parts in Voltage Regulator.* The ac voltage regulators are located in the bottom of cabinets 2, 4, and 6, behind the front cover panels. A voltage regulator must be removed from its cabinet to permit access to wiring or parts on the underside of the chassis. To do this, first set the OUTPUT VOLTAGE switch on the AC POWER SWITCHING PANEL at the top of the associated cabinet to the UNREG position, and the VOLTAGE REGULATOR switch to the OFF position. Next, remove the front cover panel, and swing it to the left side of the cabinet. If the voltage regulator is to be tested or serviced while connected to the cabinet, allow the four leads to terminal board TB1 to remain connected. In this case the voltage regulator cannot be moved more than a few inches away from the cabinet. To get at the wiring or parts, rest the voltage regulator on the rear of the chassis so that the underside of the chassis is exposed. If the voltage regulator is to be taken elsewhere for servicing, disconnect the four leads to terminal board TB1 before removing the component.

***Caution:*** The voltage regulator weighs approximately 100 pounds and may require two men to remove it easily. Be sure to grasp the handle firmly before attempting to slide it out of the cabinet. Be careful not to damage the cable.

*d. Access to Parts in LOOP BATTERY PANEL.* Access to many parts on the LOOP BATTERY PANEL chassis is made from the rear of the cabinet. If a particular part or wiring is still inaccessible, remove the panel. To do this, disengage the six connectors on the rear of the chassis, then remove the four mounting screws that hold the panel to the cabinet.

***Caution:*** The LOOP BATTERY PANEL is supported entirely by four mounting screws through the front panel. Support the panel firmly by its handle while these screws are being removed. Disconnecting this panel removes the loop battery voltage from the associated telegraph loops, resulting in a shutdown of either the transmitting or receiving part of the system.

*e. Access to Parts in Loop Battery Supplies.* The loop battery supplies are located on the floor in cabinets 1 and 3 and are accessible when the front cover panels are removed. To reach the underside of the loop battery supply chassis, the component must be removed from the cabinet. To do this, switch the loads (load A and load B) so that both are supplied by the remaining loop battery supply by setting FALL BACK SWITCHES LOAD A and LOAD B in the (RECT A or RECT B) position corresponding to the remaining loop battery supply. This allows the equipment to function while the faulty component is being serviced. Disconnect the two power cords of the loop battery from the rear of the LOOP BATTERY PANEL. Grasp the loop battery supply by the handle and withdraw.

*f. Access to Parts on AC POWER SWITCHING PANEL.* The wiring and parts on the AC POWER SWITCHING PANEL are located at the rear of the panel underneath a metal cover. To reach the wiring and parts use the procedures listed in (1) through (3) below.

(1) Place the power ON–OFF switch in the associated main power unit in the OFF position. Use the following chart to locate the appropriate main power unit.

| AC POWER SWITCHING PANEL in cabinet | Associated main power unit in cabinet |
|---|---|
| 2 | 1 |
| 4 | 3 |
| 6 | 5 |

***Warning:*** Make sure the power is off before servicing or making repairs on the AC POWER SWITCHING PANEL.

Voltages as high as 250 volts may be present in this component.

(2) Remove from the cabinet two or three of the drawer-type chassis located directly beneath the AC POWER SWITCHING PANEL to obtain working space beneath this component.

(3) Remove the two cover retaining screws and, grasp the cover of the AC POWER SWITCHING PANEL and remove it by pulling firmly to the rear. Parts on the rear of the panel are now accessible from the rear of the cabinet. Terminal board TB1 (fig. 227) is accessible from the front of the cabinet.

*g. Access to Parts in Main Power Unit.* The main power units are mounted on the floor of cabinets 1, 3, and 5 and can be reached through the rear doors of these cabinets. To get at the internal wiring of the main power unit remove the top cover as described in (1) through (3) below.

(1) Pull out two or three drawer-type chassis at the bottom of the cabinet. Make sure that they clear the main power unit.

(2) Remove the two screws that hold the top cover of the main power unit.

(3) Slide the top cover back and up to remove it. This will expose all the internal parts and connections.

***Warning:*** Before attempting to make any repairs to the main power unit, be sure to disconnect the primary power connections (par. 51) from the cabinet. Voltages as high as 250 volts may be present in the main power unit.

## 246. Voltage Measurements

Most troubles either result from abnormal voltages or produce abnormal voltages. To perform voltage measurements, follow the procedures outlined in *a* through *c* below.

*a.* Since voltage measurements are made with the power connected, be careful not to come in contact with the high voltage. Use voltmeter leads equipped with insulated test probes.

*b.* To avoid damage to the voltmeter, always begin by setting the meter on a high-voltage range. Choose a range where the full-scale reading is considerably greater than the anticipated voltage. Then, if it is necessary to obtain increased sensitivity, change the voltmeter to a lower range.

*c.* It is essential that the voltmeter resistance be very much greater than the resistance of the circuit across which the voltage is measured. Otherwise voltmeter loading will cause the indicated voltage to be lower than the actual voltage present with the voltmeter removed from the circuit. To measure dc voltages, use a voltmeter having a resistance of 20,000 ohms per volt.

## 247. Resistance Measurements

When a fault develops in a circuit, its effect will often show up as a change in the resistance values. The procedure for making resistance measurements to isolate such faults is outlined in *a* through *d* below.

*a.* Before making any resistance measurements, disconnect the power. Never attempt to measure resistance with the power connected.

*b.* When checking circuit continuity or measuring low values of resistance, set the ohmmeter on the lowest range. If a high range is used, the meter may indicate zero even if an appreciable resistance is present.

*c.* When checking for circuit leakage or measuring high values of resistance, set the ohmmeter on the highest range. If a lower range is used, the meter may indicate infinity even though there is a finite resistance in megohms.

*d.* When troubleshooting with the aid of a schematic diagram, remember that the resistance of a parallel circuit is less than the smallest resistance in the circuit. If the resistance of a circuit element is found to be less than expected make a careful study of the schematic diagram to be sure that there are no resistances in parallel with the one being measured. Before concluding that a part is defective because its resistance measures too low, disconnect the wiring and measure the resistance again to make sure that the low reading is not caused by paralleling circuits.

## 248. Resistor Tests

*a. Fixed Resistors.* When a resistor is suspected of being faulty, check it with an ohmmeter. To be certain that only the resistor is being checked, disconnect at least one end of the resistor from the circuit. The normal resistance of each resistor is shown on the appropriate schematic diagram.

*b. Variable Resistors.* Variable resistors can become defective in one of several ways. They can open, change value, develop high resistance shorts to the case, or become noisy.

(1) To check a variable resistor, tag and unsolder all connections to it.

(2) Use an ohmmeter to measure the resistance between the outside terminals of the variable resistor. The normal values of resistance are shown on the schematic diagrams.

(3) Connect the ohmmeter to one of the outside terminals and the center terminal. Rotate the control shaft with a slow and even motion from the extreme counterclockwise position to the extreme clockwise position. The indication on the ohmmeter should change steadily either from 0 ohm to the specified value or from the specified value to 0 ohm, depending on which of the outside terminals is connected to the ohmmeter. Any sudden jump or dip of the ohmmeter needle indicates that the variable resistor is defective and should be replaced.

(4) The resistance between any terminal and the case of the variable resistor should be infinite.

## 249. Level Control and Attenuator Tests

*a. Level Control Tests.* When a LEVEL ADJUST control is suspected of being faulty, check it with an ohmmeter. All of the LEVEL ADJUST controls of Multiplexer TD–97/FGT–2, Demultiplexer TD–98/FGR–3, Audio Frequency Amplifier AM–911/FG, and LEVEL CONTROL & PLATE SUPPLY are alike. The method of testing a control is outlined in (1) through (8) below.

(1) Before testing the control, tag and disconnect all connectors to it.

(2) Connect the ohmmeter to measure the resistance between terminals 1 and 3 of the control.

(3) Turn the LEVEL ADJUST control in a clockwise direction as far as it will go (position 50). The ohmmeter should show a 0-ohm reading.

(4) Rotate the control shaft counterclockwise step-by-step and observe the ohmmeter. The reading should increase for each step, reaching an indication of 1,200 ohms at the extreme counterclockwise limit (position 0).

(5) Connect the ohmmeter to measure the resistance between terminals 1 and 2 of the control.

(6) With the LEVEL ADJUST control turned as far counterclockwise as it will go (position 0) the ohmmeter should show a 600-ohm reading.

(7) Rotate the control shaft clockwise step-by-step and observe the ohmmeter. The reading should increase for each step, reaching an indication of an open circuit at the extreme clockwise limit (position 50). In any position, the resistance between terminals 2 and 3 should be the same as that between terminals 1 and 2.

(8) If the ohmmeter needle shows an abnormal reading for any step of the test, clean and lubricate the LEVEL ADJUST control (par. 234).

*b. Attenuator Tests.* When the ATTENUATOR control on the TRANSMITTER METER PANEL or RECEIVER METER PANE is suspected of being faulty, check it with an ohmmeter as outlined in (1) through (9) below.

(1) Before testing the control, tag and disconnect all connections to it.

(2) Connect the ohmmeter to measure the resistance between terminals 1 and 3 of the control.

(3) Turn the ATTENUATOR control in a clockwise direction as far as it will go (position OFF). The ohmmeter should read 7,800 ohms.

(4) Rotate the control shaft counterclockwise step-by-step and observe the ohmmeter. The reading should decrease for each step, reaching an indication of 0 ohm at the extreme counterclockwise limit (position −28).

(5) Connect the ohmmeter to measure the resistance between terminals 1 and 2 of the control.

(6) With the ATTENUATOR control turned as far clockwise as it will go (position OFF) the ohmmeter should show a 3,900-ohm reading.

(7) Rotate the control shaft counterclockwise step-by-step and observe the ohmmeter. The reading should increase for each step, reaching an indication of an open circuit at the extreme counterclockwise limit (position −28). In any position, the resistance between terminals 2 and 3 should be the same as that between terminals 1 and 2.

(8) If the ohmmeter needle shows an abnormal reading for any step of the test,

clean and lubricate the ATTENUATOR control (par. 234).

(9) If the resistance reading is still abnormal for any position of the control shaft, the ATTENUATOR control is defective and should be replaced.

### 250. Inductor and Transformer Tests

Inductors and transformers can become defective in several ways. A winding can open, several turns of a winding can become shorted, one winding can become connected internally to another winding, or a winding can become shorted to the case. Use an ohmmeter to check the winding resistance of the inductors and transformers. Check also the insulation between windings and between the windings and the case. Tag and disconnect external leads to the inductors or transformers to be certain that only the internal wiring is being checked.

## Section V. TROUBLE SECTIONALIZATION, TELEGRAPH TERMINAL AN/FGC–29

### 251. Sectionalization of Trouble

*a.* Sectionalization refers to the tracing of trouble within the AN/FGC–29 terminal to a defective component (par. 239*a*). Generally, front-panel meters, indicators, controls, and jacks are used to detect the general section in which the source of trouble lies. The built-in test facilities of the equipment are used whenever possible. To sectionalize trouble to a component, input and output signals (when available) of the component are checked. Before checking signal continuity in the suspected component the associated power sources and supplies should first be checked and eliminated as the source of trouble. A component that is suspected but still indicates normal input and output signal should be given an operational test.

*b.* When trouble is reported, it should be traced and its symptoms observed without interrupting circuits that are in operation. The signal path is traced by the use of listening tests or meter measurements, with high-impedance test equipment bridged across the input and output circuits of each component (whenever possible). MONITOR jacks are provided on the front panels of most of the components. By observing whether or not the indications at these jacks are normal, the repairman can determine the location and general nature of the trouble.

*c.* On circuits used for carrier telegraph and facsimile service, it is possible to shoot trouble using the signals that are present regardless of whether or not intelligence is being transmitted. To shoot trouble on a telephone circuit, it is necessary to transmit a test signal.

*d.* The sectionalization of trouble on operating communication circuits requires some knowledge of the normal conditions for each component. The symptoms observed when making listening tests or meter measurements to monitor operation can be readily interpreted if the normal indications for each point are known. Results of previous tests under known normal conditions should be available.

### 252. Sectionalization of Trouble in Ac Power Distribution System

(figs. 260 and 261)

*a.* Sectionalization of trouble within the ac power distribution system of the AN/FGC–29 terminal is aided primarily by indications on the AC POWER SWITCHING PANEL and, to a lesser degree, the main power unit. As a preliminary procedure, all BLOWN FUSE INDICATORS and OUTPUT VOLTAGE voltmeters should be checked. As an aid to this sectionalization procedure, refer to the ac power distribution diagrams (figs. 260 and 261). A blown fuse is a symptom of trouble within the component that it is protecting. If the replacement fuse also blows (indicating that the trouble was not in the fuse itself), take the suspected unit out of operation and take the necessary steps to localize and isolate the cause of trouble. Since each component as well as the cabinet blowers is separately fused, the component in which the overload has occurred can usually be determined quickly. The absence of power at a component can be caused by breaks in the wiring or the blowing of a main line fuse (in the main power unit). The OUTPUT VOLTAGE meter on the AC POWER SWITCHING PANEL normally meters only the 230-volt ac regulated circuits and may not indicate failure of power in cabinets 1 and 3, both of which are powered by 115 volts ac. In this case, and others where the presence of input ac power at a unit is to be determined, a simple check is made by removing the fuse on the front panel of the component in question. If power is present, the blown fuse indicator should glow.

*b.* If the OUTPUT VOLTAGE meter on any AC POWER SWITCHING PANEL does not indicate 230 volts ac when the associated voltage regulator is being used, operate the OUTPUT VOLTAGE switch to the UNREG position. This action disconnects the load from the voltage regulator and connects it directly to the 230 volts ac supplied by the main power unit. The voltage regulator in question can now be checked.

*c.* Failure of one of the loop battery supplies is indicated by its associated FAILURE INDICATOR on the LOOP BATTERY PANEL. (If both loop battery supplies fail at the same time, neither FAILURE INDICATOR will light. However, the possibility of both supplies failing at the same time is very remote.) Operate the appropriate fall back switch to connect the load from the supply that has failed to the supply that is still operative and remove the inoperative supply for further checking (par. 322).

*d.* If any of the line fuses (in the main power unit) blow, the overload is probably caused by a short in the wiring between these fuses and their loads. Since each component is individually fused, an overload in the component will blow its fuse and not the line fuse.

*e.* Throughout the above discussion, no attempt has been made to give the symptoms accompanying failure of the ac power distribution system. The absence of any reading on the OUTPUT VOLTAGE meter on the ac power switching panels would normally indicte that no ac power is present.

*f.* To aid in the sectionalization of troubles in the ac power distribution circuit, it should be noted that cabinets 1 and 2 operate from the main power unit in cabinet 1. The main power unit in cabinet 3 furnishes 115 volts ac power for cabinet 3 and 230 volts ac power for cabinet 4 and part of cabinet 5. The main power unit in cabinet 5 furnishes 230 volts ac power for cabinet 6 and part of cabinet 5 and also grounded 230 volts ac power for the combiners in cabinets 4, 5, and 6.

## 253. Sectionalization of Trouble in Loop Battery Voltage Distribution System

(figs. 147 and 148)

*a.* To aid in the sectionalization of troubles within the loop battery voltage distribution system refer to figures 147 and 148. A blown fuse caused by a loop circuit fault in the AN/FGC–29 terminal is indicated by the corresponding BLOWN FUSE INDICATOR on the LOOP BATTERY PANEL. However, an overload condition in the external telegraph loop associated with a transmitter is indicated by a blown LOOP FUSE on the transmitter front panel.

*b.* The loop currents are checked by the loop current meters on the TRANSMITTER METER PANEL and the RECEIVER METER PANEL. Connect the LOOP MONITOR jacks on the transmitter and combiner front panels to the INPUT jack for the LOOP CURRENT METER. The meter should indicate a marking current of 20 ma or 60 ma depending on the loop current being used.

## 254. Sectionalization of Trouble in B-Plus Power Distribution System

(figs. 145 and 146)

*a.* Distribution of B-plus power within the transmitting terminal is shown in figure 145. Absence of B-plus power (+200 volts dc) at one of the transmitters is not directly indicated on the front panels unless it is caused by a blown fuse in the component in which case the +200 VDC BLOWN FUSE INDICATOR goes on. Failure of either power supply in the LEVEL CONTROL & PLATE SUPPLY is indicated by the PLATE SUPPLY A FAILURE or PLATE SUPPLY B FAILURE indicator. If one of these supplies fails, its load is manually transferred to the supply still in operation. For this purpose, the CHANNELS 1–8 and AMPL A ON POWER SUPPLY and CHANNELS 9–16 and AMPL B ON POWER SUPPLY switches are used. The failed power supply can then be checked and repaired.

*b.* Distribution of B-plus power between receivers and combiners within the receiving terminal is shown in figure 146. The B-plus power (+200 volts dc) is derived from the plate supply in each receiver. In addition to supplying power to the receiver, it also supplies B-plus power to the associated circuits in the associated combiner. The absence of B-plus power at the receiver or combiner is not directly indicated at the front panels, except when the ac power input to the receiver is interrupted by an opened fuse in which case a blown fuse indicator on the receiver goes on.

## 255. Sectionalization of Trouble in Remote Control System

(figs. 78, 130, 141, and 142)

Each diversity switch pair at the remote control station is provided with a signal light to indicate the position of the corresponding DIVERSITY

switch on the associated transmitter or combiner. If the equipment is operating in 2-channel diversity, the remote 4-channel diversity indicator should be extinguished and the manual control knob for the DIVERSITY switch should be in the 2 CHANNEL position. If it is not at this position, either the interunit cabling, the —130-volt supply, or the DIVERSITY switch attenuator should be checked. When the 4-channel diversity switch at the remote control station is operated, the remote indicator should go on and the DIVERSITY switch should turn to the 4 CHANNEL position.

## 256. Sectionalization of Trouble in Signal Path System Transmitting Terminal

(figs. 248 and 136)

*a. General.* Sectionalization of trouble in the signal path system is accomplished by two methods: listening tests and meter measurements. The listening tests will prove to be more useful after experience in identifying different characteristic tones. In certain circuits where several tones are present simultaneously, the listening tests are more difficult to interpret. However, even in these circuits, sufficient information is presented in *b* and *c* below to enable the experienced trouble shooter to sectionalize the source of trouble as closely as possible. Meter measurements as well as listening tests are subject to changes when the signals in the receiving terminal are derived from a radio circuit operating over a skywave path that is subject to selective fading. Changes in level, because of this fading action, should be recognized as a normal condition and not necessarily indicative of trouble in the equipment.

*b. Listening Tests.* Listening tests are made with the high-impedance Electrical Headset H–110/G. Information obtained in this manner is of a qualitative instead of a quantitative nature, and furthermore, may have to be confirmed by meter measurements. The MONITOR jacks on the front panels allow listening tests to be made without interrupting or opening the circuits under test. During the listening tests, it may be necessary to check the output of a component at its EQUIP jacks. (The EQUIP jacks provide for input and output connections to a component.) The EQUIP jacks, when used, disconnect the component from its associated line and interrupt the signal path. The LINE (or BUS) jacks provide a convenient point for checking the connections between components.

(1) *Transmitter.*

(*a*) *CARRIER MONITOR jacks.* The frequency-shift signals should be heard at the CARRIER MONITOR jacks. The frequency of the signals in each channel will vary with the channel being checked. The frequency should be between 1,740 and 3,020 cps.

(*b*) *CHANNEL OUTPUT jacks.* The signal heard at the CHANNEL OUTPUT jacks is essentially the same as that at the CARRIER MONITOR jacks. When the CHANNEL OUTPUT jacks are used, the transmitter channel is disconnected from the sending bus. In this way, the transmitter channel output can be checked separately from the output of the other transmitters.

(2) *SUBGROUP MODULATOR.*

(*a*) *DIRECT PATH INPUT MONITOR jacks.* The signal heard at the DIRECT PATH INPUT MONITOR jacks is a distinctive mixture of clear audible tones in the frequency range 1,740 to 3,020 cps. The odd-numbered channel signals are checked at these jacks.

(*b*) *TRANSLATED PATH INPUT MONITOR jacks.* The signal at the TRANSLATED PATH INPUT MONITOR jacks, like that at the DIRECT PATH INPUT monitor jacks, is a distinctive mixture of clear audible tones in the frequency range 1,740 to 3,020 cps. The input at these jacks is the even-numbered channel signals.

(*c*) *OUTPUT MONITOR jacks.* The signal at the OUTPUT MONITOR jacks is a distinctive mixture of low-level clear audible tones in the frequency range 380 to 3,020 cps.

(3) *LEVEL CONTROL & PLATE SUPPLY.* The LEVEL CONTROL & PLATE SUPPLY amplifies the output of the SUBGROUP MODULATOR. The signal at this component should be a distinctive mixture of clear audible tones in the frequency range 380 to 3,020 cps.

(*a*) *INPUT MONITOR jacks.* The signal at the INPUT MONITOR jacks should be the same as that described in (2) (*c*) above.

(*b*) *OUTPUT MONITOR jacks.* The signal at the OUTPUT MONITOR jacks should be the same as that at the INPUT MONITOR jacks, but at a much higher level.

(4) *3KC SEND BAND TEST PANEL.* The signals at the jack groups on the 3KC SEND BAND TEST PANEL depend on the diversity option and system arrangement for the equipment (pars. 54–56). The following normal indications at the jack groups are for the arrangement shown in figure 248.

(*a*) *JACK GROUP 1 MONITOR jacks.* The MONITOR jacks for JACK GROUP 1 check the telegraph signal output of the LEVEL CONTROL & PLATE SUPPLY. The signal should be a distinctive mixture of clear audible tones in the frequency range 380 to 3,020 cps.

(*b*) *JACK GROUP 2 through JACK GROUP 4 MONITOR jacks.* These jacks check the telephone or facsimile signal input to the AN/FGC–29 terminal. The normal telephone test signal is a clear steady tone at 1,000 cps. When the circuit operates on facsimile signals, the signal heard should be a clear steady tone if a test signal is being used. On an operating circuit, the signal is a varying tone in the vicinity of 2,000 cps.

(5) *Multiplexer TD–97/FGT–2.*

(*a*) *INPUT MONITOR jacks.* The nature of the input signal to the DIRECT PATH or TRANSLATED PATH INPUT MONITOR jack varies, depending on the diversity option and system arrangement being used (pars. 54–56). The normal indication for carrier telegraph signals is a distinctive mixture of clear audible tones, all in the frequency range 380 to 3,020 cps. The normal telephone test signal is a clear steady tone with a frequency of 1,000 cps. The normal facsimile test signal is a clear steady tone. On an operating circuit the facsimile signal is a tone of varying frequency in the vicinity of 2,000 cps.

(*b*) *OUTPUT MONITOR jacks.* The nature of the signals at the OUTPUT MONITOR jacks depends on the signals at the INPUT MONITOR jacks. Signals passing through the translated path are inverted and shifted to lie in the frequency range between 3,265 and 5,915 cps so that they sound different at the OUTPUT MONITOR jacks than do signals passing through the direct path. Signals present at the DIRECT PATH INPUT MONITOR jacks should be heard unchanged in the OUTPUT MONITOR jacks. Signals at the TRANSLATED PATH INPUT MONITOR jacks should be heard in the OUTPUT MONITOR jacks as audible tones of higher frequency. If signals are present in both INPUT MONITOR jacks, a mixture of the signals should be heard in the OUTPUT MONITOR jacks.

*c. Meter Measurements.* Meter measurements are made preferably with the test equipment built into the AN/FGC–29 terminal. It may occasionally be necessary to use some of the test equipment listed in paragraph 241. When measurements are being made on the transmitting terminal, the TRANSMITTER METER PANEL is used, in particular the LEVEL METER. This meter can be used either for bridging or terminating measurements. For bridging measurements of signal level, use the BRIDGING jacks of the meter. On 600-ohm circuits, the LEVEL METER reads signal levels in dbm. The meter is calibrated to read vu, which are applicable when measuring speech or other audio signals. Dbm and vu are equal numerically for telegraph or facsimile signals, as well as for a telephone test tone. Bridging measurements can be made by connecting the LEVEL METER to the following jacks in the transmitting terminal.

| Component | Input jacks | Output jacks |
|---|---|---|
| Transmitter | None | CARRIER MONITOR.* |
| SUBGROUP MODULATOR. | INPUT MONITOR. | OUTPUT MONITOR. |
| LEVEL CONTROL & PLATE SUPPLY. | INPUT MONITOR. | OUTPUT MONITOR. |
| 3 KC SEND BAND. TEST PANEL. | None | MONITOR. |
| Multiplexer | INPUT MONITOR. | OUTPUT MONITOR. |

* Meter readings do not indicate signal level in dbm or vu, but measure an internal signal within the component, which is proportional to input or output signal.

When making terminating measurements of signal level in 600-ohm circuits, use the TERMINATING jacks of the LEVEL METER. Terminating measurements, since they interrupt the continuity of the circuit under test, cannot be made without interfering with traffic operation. Terminating measurements can be made by connecting the LEVEL METER to the following jacks in the transmitting terminal.

| Component | Input jacks | Output jacks |
|---|---|---|
| Transmitter | None | CHANNEL OUTPUT. |
| SUBGROUP MODULATOR. | INPUT BUS | OUTPUT EQUIP. |
| LEVEL CONTROL & PLATE SUPPLY. | INPUT LINE | OUTPUT EQUIP. |
| 3KC SEND BAND TEST PANEL. | EQUIP OUT | None. |
| Multiplexer | INPUT LINE | OUTPUT EQUIP. |

(1) *Transmitter.* The transmitter output at the CHANNEL OUTPUT jacks should be −15 dbm ±2 db. To check the output frequency of the transmitter, follow the procedure outlined in paragraph 96. The signal level at the CARRIER MONITOR jacks should be as measured and recorded in paragraph 96*a*(16) or (18).

(2) SUBGROUP MODULATOR. The input level to the SUBGROUP MODULATOR at the INPUT BUS and INPUT MONITOR jacks should be −15 dbm ±2 db, per channel or −6 dbm for eight channels. The output level at the OUTPUT EQUIP and OUTPUT MONITOR jacks should be −45 dbm ±1 db per channel or −33 dbm for 16 channels.

(3) LEVEL CONTROL & PLATE SUPPLY. The normal input level to the LEVEL CONTROL & PLATE SUPPLY at the INPUT LINE or INPUT MONITOR jacks should be −45 dbm ±1 db per channel or −33 dbm for 16 channels. The normal output levels at the OUTPUT EQUIP or OUTPUT MONITOR jacks should be −10 dbm (space diversity) or −4 dbm (frequency diversity) per channel; or +2 dbm and +8 dbm respectively for 16 channels. The maximum output level should not exceed 0 dbm per channel or +12 dbm for 16 channels.

(4) 3KC SEND BAND TEST PANEL. The operating levels depend on the nature of the signals as indicated below.

(*a*) *Telegraph, space diversity.* The level per telegraph channel is −10 dbm. The corresponding multichannel level for 16 channels at JACK GROUP 1, EQUIP OUT, or MONITOR jack should be +2 dbm.

(*b*) *Telegraph, frequency diversity.* The level per telegraph channel is −4 dbm. The corresponding multichannel level for 16 channels at JACK GROUP 1, EQUIP OUT, or MONITOR jacks, should be +8 dbm.

(*c*) *Telephone.* The test tone level should be −4 dbm at the EQUIP OUT or MONITOR jacks of the associated jack groups.

(*d*) *Facsimile.* The test tone level at the output of the facsimile transmitter is 0 dbm, as measured at the EQUIP OUT or MONITOR jacks, of the associated jack group.

(5) *Multiplexer.* Check the output of the multiplexer at its OUTPUT EQUIP or OUTPUT MONITOR jacks.

(*a*) *Telegraph.* The correct power level for the 16 carrier telegraph channels

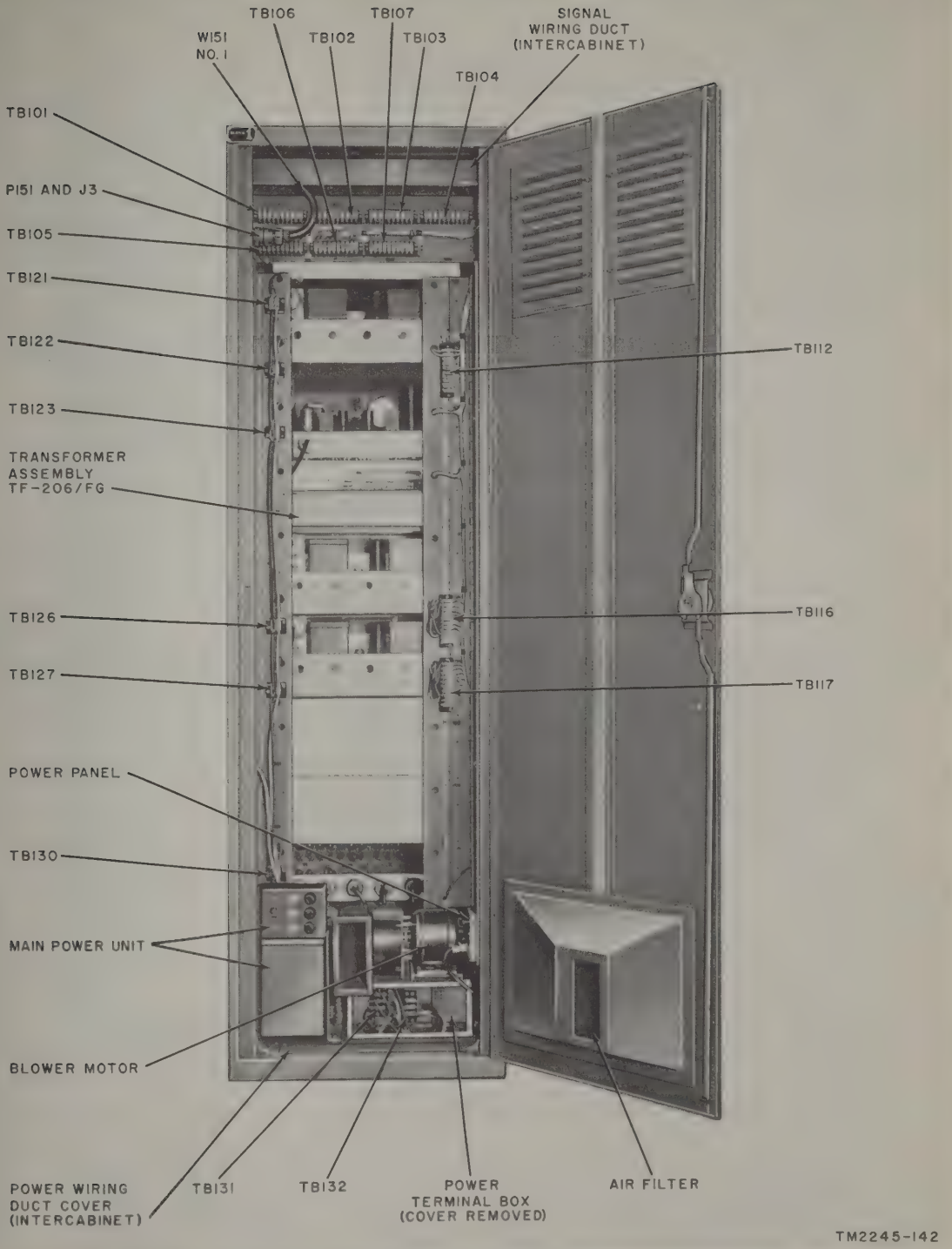



*Figure 162. Cabinet 1, rear view.*

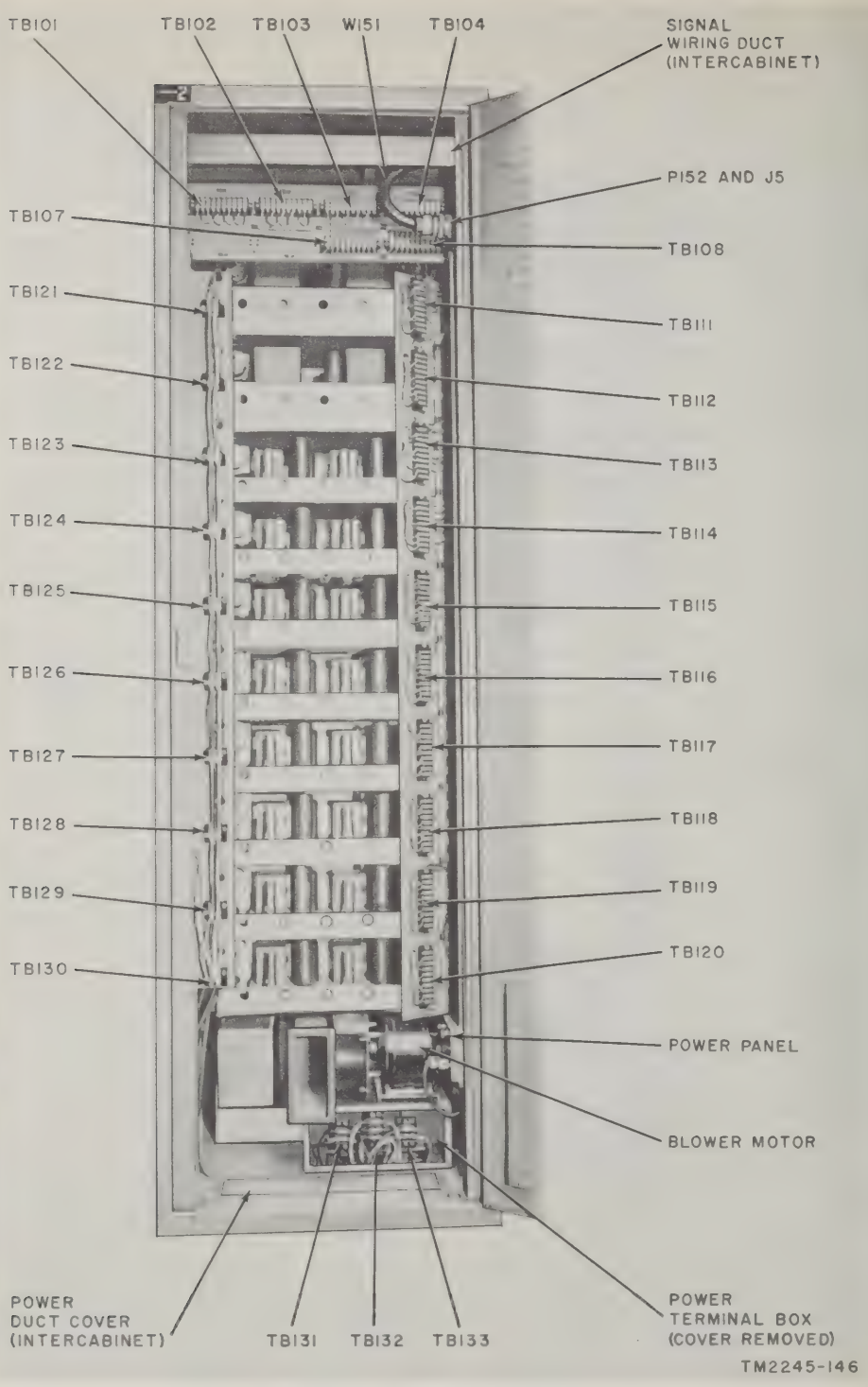



*Figure 163. Cabinet 2, rear view.*

(16 tones) at the multiplexer output is +2 dbm, corresponding to −10 dbm per channel. For frequency diversity, the correct levels at the output are +5 dbm for 16 channels (32 tones) and −7 dbm per channel (2 tones). These levels apply only to frequency diversity options A and F (par. 56).

(*b*) *Telephone.* The correct level for a telephone test tone at the multiplexer output is −4 dbm.

(*c*) *Facsimile.* The correct level for facsimile test tone at the multiplexer output is 0 dbm.

## 257. Sectionalization of Trouble in Signal Path System, Receiving Terminal

(figs. 249, 252, and 253)

*a. General.* Sectionalization of trouble within the signal path of the receiving terminal is performed in a manner similar to that described for the transmitting terminal (par. 256*a*). As before, listening tests and meter measurements are made to localize the trouble to a particular component.

*b. Listening Tests.* Listening tests provide the repairman with audible indications of possible troubles within the receiving terminal. Refer to paragraph 256*b* for a discussion of these tests. Perform the tests on the components of the terminal, as described in (1) through (6) below.

(1) *Audio Frequency Amplifier AM–911/FG.* The listening tests performed on one amplifier section of Audio Frequency Amplifier AM-911/FG should be repeated for the other.

(*a*) *INPUT MONITOR jacks.* The nature of the signals heard at the INPUT MONITOR jacks depends on the type of signal present and may include telephone, facsimile, or multichannel telegraph signals. While it is difficult to recognize all the signals, it should be possible to determine whether they are normal or not. When the amplifier is used on 3-kc lines only one type of service can be heard; the normal indication at these jacks is audible tones, all below 3,020 cps. For 6-kc lines, the tones should extend up to 6,000 cps and may be a mixture of two types of service. The volume level of these tones will be low.

(*b*) *OUTPUT MONITOR jacks.* The normal indication at the OUTPUT MONITOR jacks is similar to that heard at the INPUT MONITOR jacks, but at a higher volume level.

(2) *Demultiplexer TD–98/FGR–3.*

(*a*) *INPUT MONITOR jacks.* The nature of the signals heard at the INPUT MONITOR jacks depends on the type of signals present. While it is difficult to recognize all the signals, it should be possible to determine whether they are normal. The normal indication at these jacks is the same as at the output of the associated audio frequency amplifier and contains audible tones below 6,000 cps.

(*b*) *OUTPUT MONITOR jacks.* The nature of the signals heard at the DIRECT PATH OUTPUT MONITOR jacks or TRANSLATED PATH OUTPUT MONITOR jacks will depend on whether the circuits are being used for telegraph, telephone, or facsimile service. When carrier telegraph signals are present, the normal indication is a distinctive mixture of clear audible tones, from 380 to 3,020 cps. The normal facsimile test signal is a clear steady tone. On an operating circuit, the signal is a varying tone in the vicinity of 2,000 cps.

(3) *3KC RECEIVE BAND TEST PANEL.* The nature of the signals heard at the MONITOR jacks on the 3KC RECEIVE BAND TEST PANEL depends on whether the circuits are being used for telegraph, telephone, or facsimile service. These signals should be the same as those at the OUTPUT MONITOR jacks on the demultiplexers ((2)(*b*) above).

(4) *SUBGROUP DEMODULATOR.* The signals at the INPUT MONITOR jacks on the SUBGROUP DEMODULATOR are carrier telegraph signals. The normal indication at the jacks is a distinctive mixture of clear audible tones from 380 to 3,020 cps.

(5) *Receiver.* The normal telegraph signals heard at the MONITOR jacks on the receiver is a single-channel, frequency-shift tone, falling in the range from 1,740 to 3,020 cps. If the signal is

obtained during normal traffic service, it is subject to fading, so that variations in signal level are not conclusive evidence of malfunctioning.

(6) *Combiner.* There are no jacks on the combiner that permit listening tests.

*c. Meter Measurements.* Meter measurements provide the repairman with a quantitative indication of possible trouble in the receiving terminal. Refer to paragraph 256c for a discussion of these tests. Perform the meter measurements indicated in (1) through (8) below.

(1) *Bridging measurements.* The bridging measurements are made with the LEVEL METER on the RECEIVER METER PANEL at the test jacks tabulated below. The measurements of signal level are in dbm, except as otherwise noted.

| Component | Input jacks | Output jacks |
|---|---|---|
| Audio frequency amplifier. | INPUT MONITOR. | OUTPUT MONITOR. |
| Demultiplexer | INPUT MONITOR. | OUTPUT MONITOR. |
| 3KC RECEIVE BAND TEST PANEL. | None | MONITOR. |
| SUBGROUP DEMODULATOR. | INPUT MONITOR. | None. |
| Receiver | MONITOR* | METER.* |

*Meter readings do not indicate signal level in dbm or vu, but measure an internal signal within the component, which is proportional to input or output signal.

(2) *Terminating measurements.* Terminating measurements are made at the test jacks tabulated below; the measurement of signal level is in dbm, except as otherwise noted.

| Component | Input jacks | Output jacks |
|---|---|---|
| Audio frequency amplifier. | INPUT LINE | OUTPUT EQUIP. |
| Demultiplexer | INPUT LINE | OUTPUT EQUIP. |
| 3KC RECEIVE BAND TEST PANEL. | LINE OUT | None. |
| SUBGROUP DEMODULATOR. | INPUT LINE | None. |
| Receiver | LINE* | None. |

*Meter reading made with BRIDGING jacks of LEVEL METER or RECEIVER METER PANEL. Reading does not indicate signal level in dbm.

(3) *Audio Frequency Amplifier AM–911/FG.* The signal level at the INPUT MONITOR jacks is usually too low to be measured except with a sensitive decibel meter. Furthermore, the normal input level varies considerably for different line facilities and operating conditions. Similarly, the signal level at the OUTPUT MONITOR jacks varies considerably for different types of signals. The level also depends on whether the signals are in the transmitting or receiving equipment. In the receiving terminal, the signal level also depends on the location of audio frequency amplifier. It should be recognized that variations in signal level caused by fading are not symptoms of trouble. Normally, the levels at the jacks should be compared with readings obtained with the same type of signals present and the equipment operating satisfactorily. If such readings are not available, an approximate check can be made by comparing the signal level at the other end of the line facility with the level at the OUTPUT MONITOR jacks. Since the audio frequency amplifier serves only to compensate for the loss and frequency characteristics of the line, the two levels should be about the same.

(*a*) *6-kc facilities.* For 6-kc facilities (demultiplexer at receiving terminal), the output levels at the OUTPUT MONITOR jacks should be as follows: For telegraph signals, the correct power level for 16 carrier telegraph channels is −3 dbm, corresponding to −15 dbm per channel; for frequency diversity operation through one radio channel, each telegraph signal is received as two different tones. In the latter case, the correct power levels are 0 dbm for 16 channels (32 tones), corresponding to −12 dbm per channel (2 tones). These values apply only to frequency diversity options A and F (par. 57). For telephone signals, the correct level for a test tone is −9 dbm. Finally, for facsimile signals, the correct level is −5 dbm.

(*b*) *3-kc facilities.* For 3-kc facilities (demultiplexer at radio receiver site), the

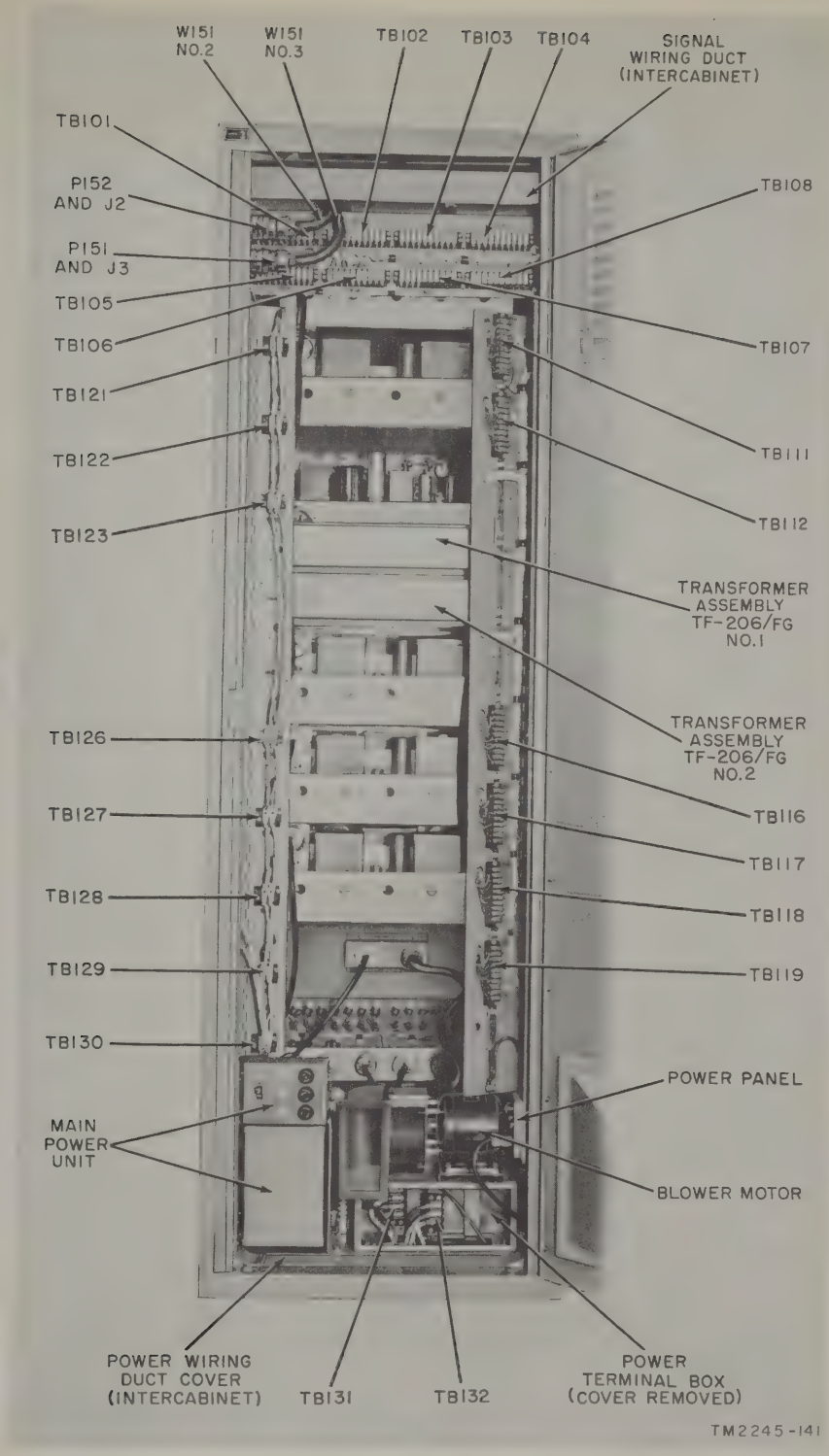



*Figure 164. Cabinet 3, rear view.*

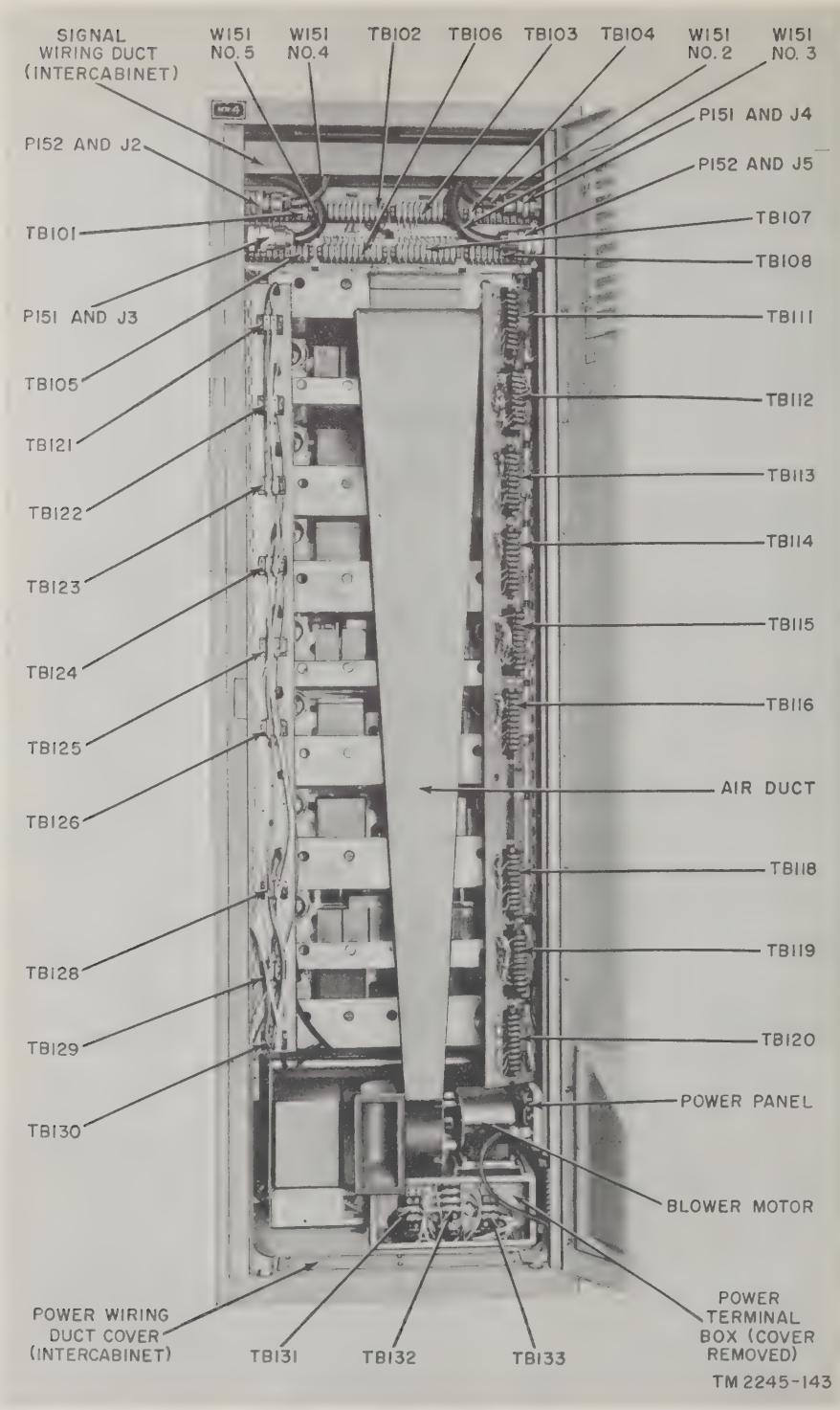



*Figure 165. Cabinet 4, rear view.*

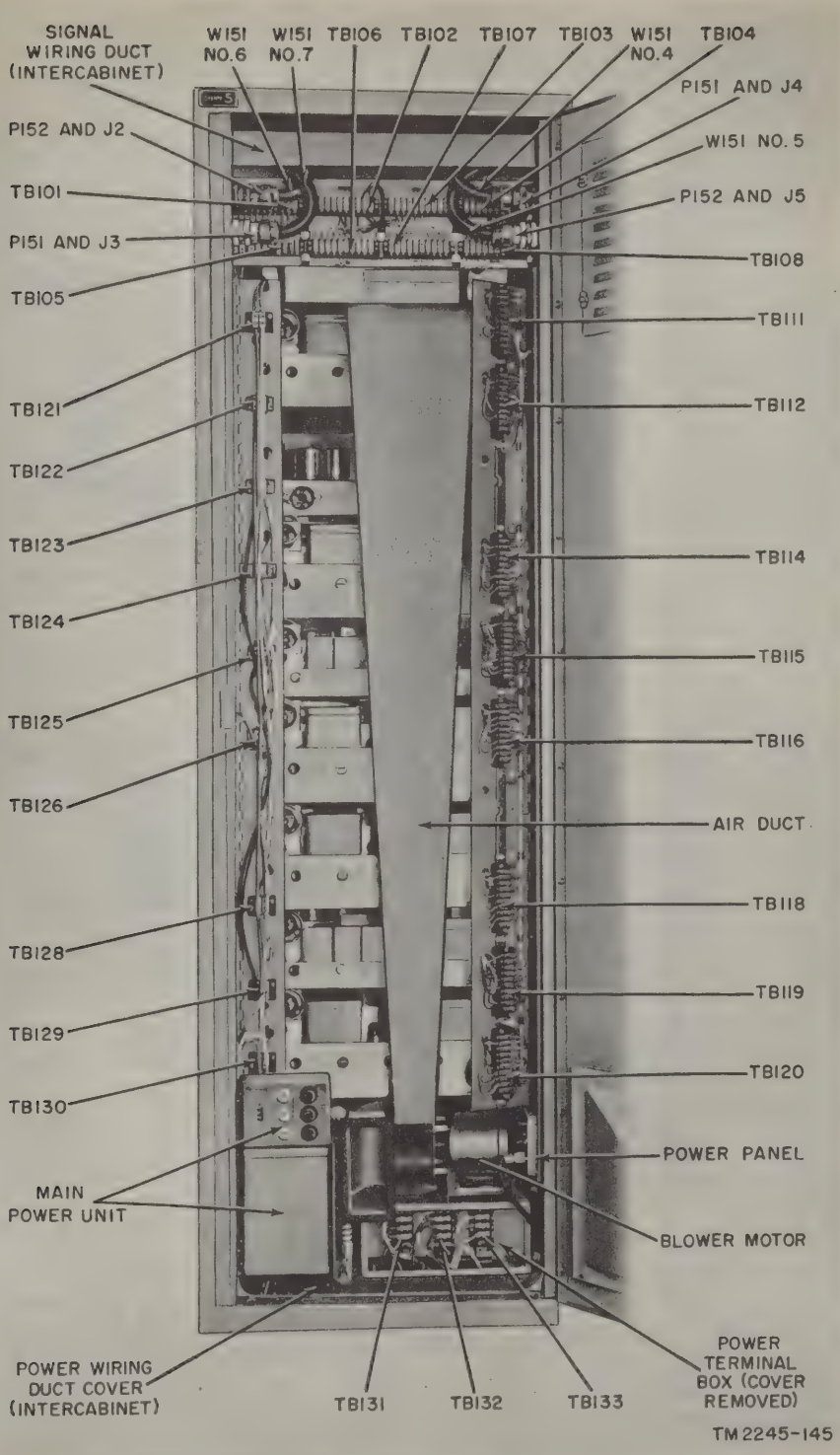



*Figure 166. Cabinet 5, rear view.*

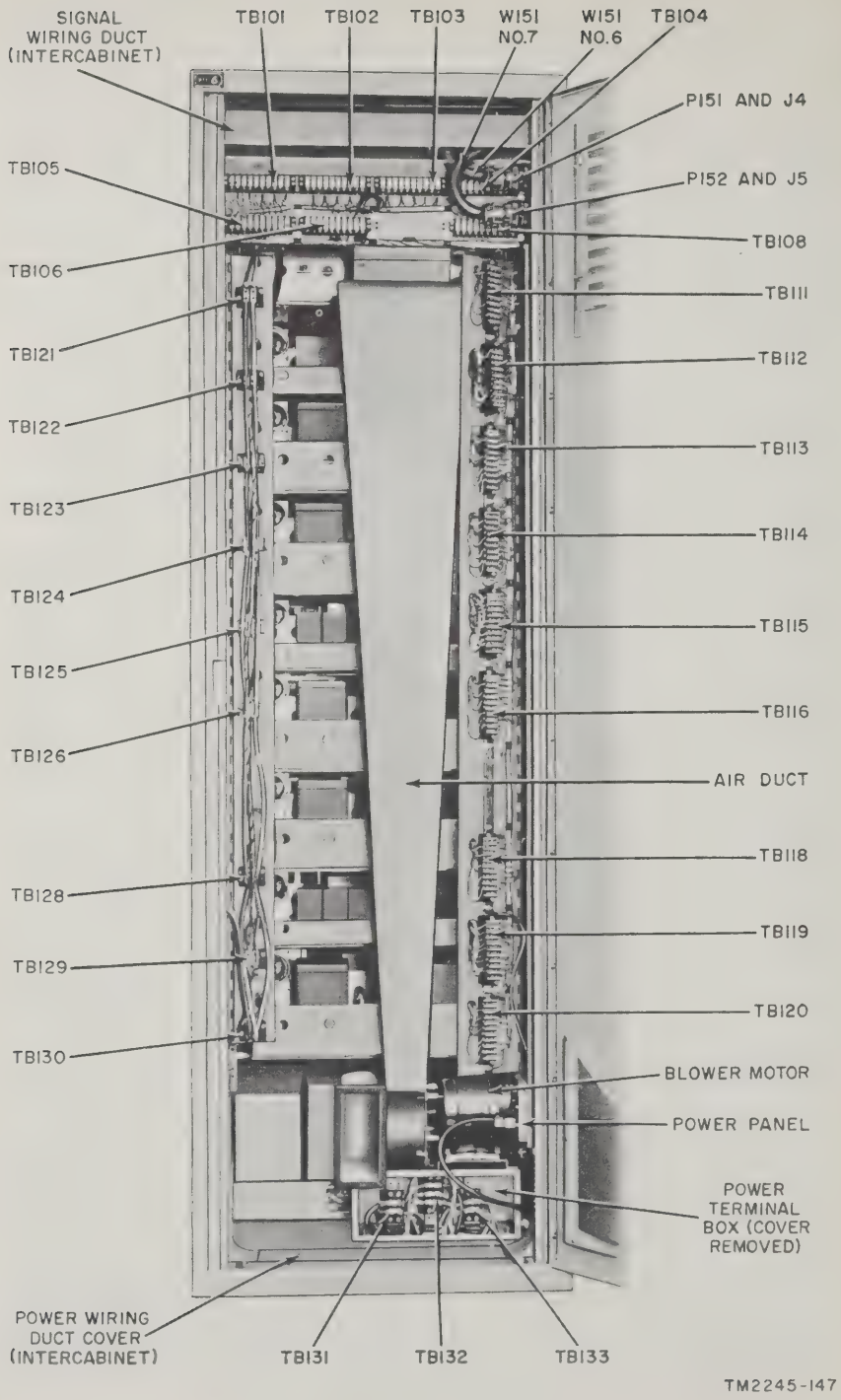



*Figure 167. Cabinet 6, rear view.*

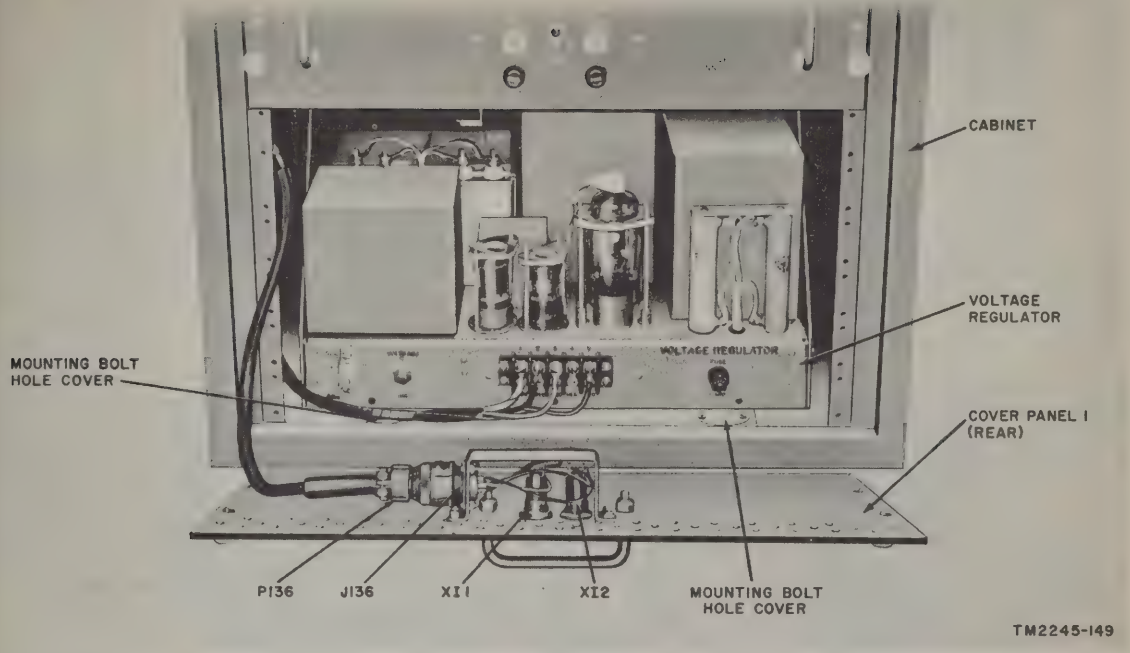



*Figure 168. Voltage regulator in position.*

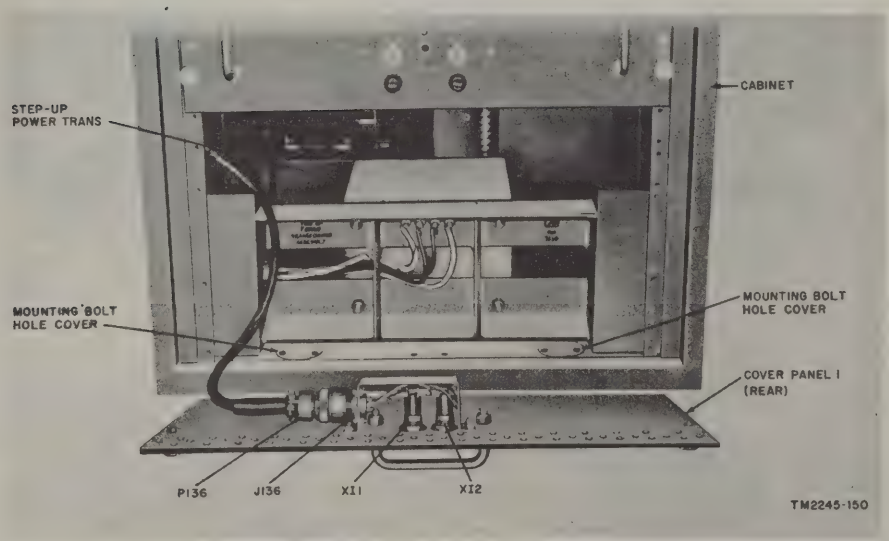



*Figure 169. Step-up power transformer.*

output levels at the OUTPUT MONITOR jacks should be as follows. The correct power level for 16 carrier telegraph channels is +12 dbm, corresponding to 0 dbm per channel; for telephone signals, the correct level for a test tone is +1 dbm. The correct level for facsimile signals is 0 dbm.

(4) *Demultiplexer TD–98/FGR–3.* The correct levels for the input signals of the demultiplexer are the same as the output levels of the audio frequency ampli-

fier used on 6-kc facilities ((3)(*a*) above). The correct levels for the output signals of the demultiplexer are the same as the output levels of the audio frequency amplifier used on 3-kc facilities ((3)(*b*) above).

(5) *3KC RECEIVE BAND TEST PANEL.* The correct levels for the MONITOR jacks are the same as the correct output levels for the demultiplexer.

(*a*) *Telegraph.* The correct power level for 16 carrier telegraph channels is +12 dbm, corresponding to 0 dbm per channel.

(*b*) *Telephone.* The correct level for a telephone test tone is +1 dbm.

(*c*) *Facsimile.* The correct level for facsimile signals in 0 dbm.

(6) *SUBGROUP DEMODULATOR.* The correct telegraph signal level at the INPUT MONITOR jacks is the same as for the MONITOR jacks on the associated jack group of the 3KC RECEIVE BAND TEST PANEL (+12 dbm for 16 telegraph channels).

(7) *Receiver.* Since there are no output monitor jacks on the receiver front panel (the MONITOR and METER jacks check only internal circuits), it is not possible to definitely sectionalize causes of trouble within the receiver by the use of front panel jacks. However, the MONITOR jacks are used to check the delay amplifier operation. The METER jacks, when used in conjunction with the METER SWITCH and the LEVEL METER, check the input to the expander circuit (or the output of the gain control circuit). The signal level at the MONITOR jack, with the receiving terminal operating in normal traffic service, should be −20 dbm. The signal level at the METER jacks should be about −22 dbm. This level may vary widely as a result of selective fading on the radio circuit. The maximum reading of the meter is indicative of the signal level.

(8) *Combiner.* As with the receiver discussed in (7) above, it is not possible to sectionalize causes of trouble to the combiner. While the component has output (LOOP) jacks, it has no input jacks to permit such

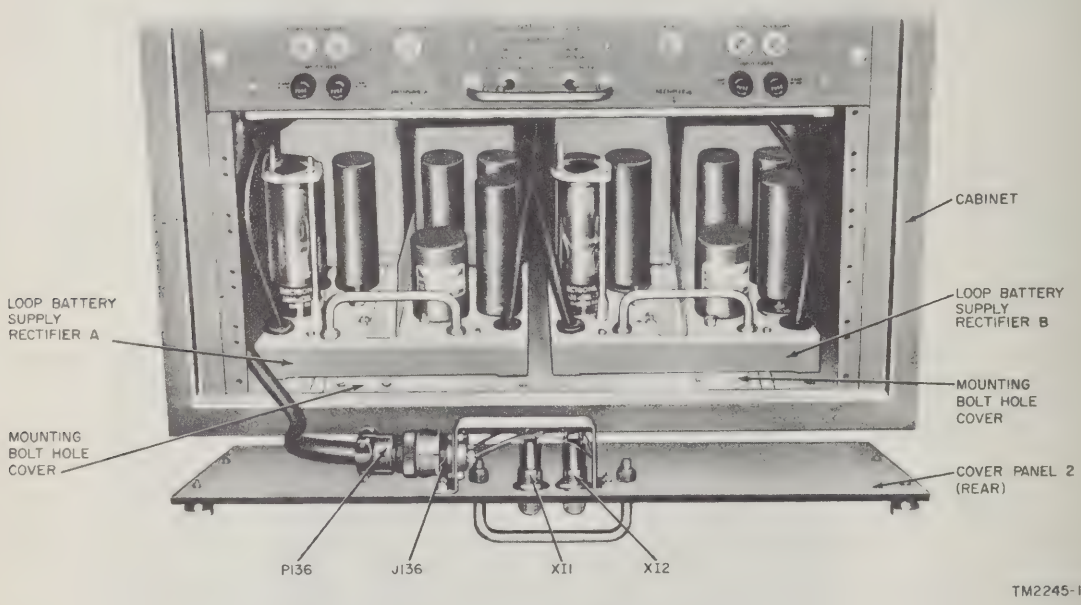



*Figure 170. Loop battery supplies in position.*

sectionalization. The LOOP MONITOR jacks, when used with the LOOP CURRENT METER on the RECEIVER METER PANEL, should indicate a marking current of 20 or 60 ma, depending on which is being used by the loop.

## Section VI. TROUBLESHOOTING, TRANSMITTER

### 258. Operational Test, TRANSMITTER CHANNELS 1 and 2 Through TRANSMITTER CHANNELS 15 and 16

The general procedure to be followed in performing an operational test is described in paragraph 239*b*. To test a transmitter it is necessary to check the dc loop circuits and the carrier channel circuits of each of the two channels in the transmitter both for 2-channel and 4-channel diversity operation. Before starting the test, note the settings of the following controls (figs. 44 and 45) and restore them to these settings after the test is completed.

| Control | Quantity |
|---|---|
| DIVERSITY switch | 1 |
| IDLE-NORMAL switch | 2 |
| LOOP CURRENT SELECTOR switch | 2 |
| LOOP TERMINATION switch | 2 |

*a. Test Setup.* The transmitter remains in place and connected to its normal power supply as installed. Frequency Meter FR–67/U or Frequency Counter AN/USM–26 is required to test the transmitter and are connected as described in *b* and *c* below. Close the external transmitting loops of the transmitter to ground before starting the test.

*b. Two-Channel Diversity Operation.* This test checks the performance of the odd-numbered channel and the even-numbered channel separately.

(1) *Odd-numbered channel.* The transmitter controls referred to in this paragraph, with the exception of the DIVERSITY switch, will be those associated only with the odd-numbered channel (left side of the chassis drawer).

(*a*) On the front panel, set the DIVERSITY switch to the 2 CHANNEL position and the IDLE-NORMAL switch to the NORMAL position, (Check to see that the IDLE INDICATOR glows when the IDLE-NORMAL switch is in the IDLE position).

(*b*) Set the internal controls. Set the LOOP TERMINATION switch to the NEG position and the LOOP CURRENT SELECTOR switch to the 60 MA position.

(*c*) Connect the DOTTER OUTPUT jack on the TRANSMITTER METER PANEL to the loop EQUIP jack of the transmitter.

(*d*) Set the MARK–SPACE–DOT switch of the DOTTER on the TRANSMITTER METER PANEL (fig. 66) to the MARK position.

(*e*) Connect the LOOP CURRENT METER INPUT jack on the TRANSMITTER METER PANEL to the loop MONITOR jack on the transmitter.

(*f*) Adjust the LOOP CURRENT ADJUST control to obtain a reading of exactly 60 ma on the LOOP CURRENT METER.

(*g*) Connect the CHANNEL OUTPUT jacks of the transmitter to the TERMINATING jacks of the LEVEL METER. Set the CARRIER LEVEL control of the transmitter fully clockwise. The LEVEL METER should read not less than −10 dbm. Reset the level to −15 dbm.

(*h*) Connect the CARRIER MONITOR jacks on the transmitter to the SPARE AMPL INPUT jacks on the LEVEL CONTROL & PLATE SUPPLY.

(*i*) Connect Frequency Meter FR–67/U to the SPARE AMPL OUTPUT jacks of the LEVEL CONTROL & PLATE SUPPLY. The frequency meter should read the marking frequency ±1 cps of the channel under test (par. 7*c*).

(*j*) Set the MARK-SPACE-DOT switch in the SPACE position. The LEVEL METER should read within 1.5 db of

the reading obtained in (*g*) above. The frequency meter should read the spacing frequency ±1 cps of the channel under test (par. 7*c*).

(*k*) Set the MARK–SPACE–DOT switch to the DOT position. The LOOP CURRENT meter should read approximately 30 ma. Depress the BIAS switch on the TRANSMITTER METER PANEL; the LOOP CURRENT meter should read 60 ma ±2 ma.

(*l*) Remove the patching cord plug from the loop EQUIP jack of the transmitter.

(*m*) Set the LOOP TERMINATION switch in the GRD position, and set the LOOP CURRENT SELECTOR in the 20 MA position. Adjust the LOOP CURRENT ADJUST control to obtain a reading of 20 ma on the LOOP CURRENT METER.

(*n*) The LEVEL METER should read −15d bm. The frequency meter should read the marking frequency of the channel under test ±1 cps.

(*o*) Insert an open plug in the loop EQUIP jack of the transmitter. The LEVEL METER should read within 1. 5 db of the reading obtained in (*n*) above. The frequency meter should read the spacing frequency of the channel under test ±1 cps.

(*p*) Set the LOOP TERMINATION switch to the POS position. The same readings should be obtained as in (*o*) above.

(*q*) Connect Multimeter TS–352/U, arranged to read 50 volts dc at 20,000 ohms per volt, between terminal 5 (+) on terminal board TB2 and terminal 1 (−) on terminal board TB3. The multimeter should read approximately 35 volts.

(*r*) Disconnect the multimeter from the transmitter and remove the patch cord from the loop EQUIP jack. Set the LOOP TERMINATION SWITCH to the GRD position and the LOOP CURRENT switch to the 60 MA position. Readjust the loop current to 60 ma if necessary in accordance with (*e*) and (*f*) above.

(2) *Even-numbered channel.* To check the performance of the even-numbered channel in a transmitter drawer, repeat the test described in (1)(*a*) through (*r*) above using the corresponding jacks and controls for the even-numbered channel (right side of chassis).

*c. Four-channel Diversity Operation.* To check the performance of a transmitter for 4-channel diversity operation, perform the tests described in (1) through (11) below.

(1) Check to see that the LOOP TERMINATION switches (both channels) are in the NEG position. Make sure that both LOOP CURRENT SELECTOR switches are in the 60 MA position and both IDLE–NORMAL switches are in the NORMAL position.

(2) Check to see that the DIVERSITY switch (S5) is operable from the remote control station. Set the DIVERSITY switch in the 4 CHANNEL position.

(3) Connect the OUTPUT jack of the DOTTER on the meter panel to the odd-numbered loop EQUIP jack of the transmitter.

(4) Set the MARK–SPACE–DOT switch of the DOTTER on the TRANSMITTER METER PANEL to the MARK position.

(5) Connect the CARRIER MONITOR jacks of the odd-numbered channel to the SPARE AMPL INPUT jacks on the LEVEL CONTROL & PLATE SUPPLY.

(6) Connect Frequency Meter FR–67/U to the SPARE AMPL OUTPUT jacks of the LEVEL CONTROL & PLATE SUPPLY. The frequency meter should read the marking frequency ±1 cps of the odd-numbered channel under test (par. 7*c*).

(7) Change the MARK–SPACE–DOT switch to the SPACE position. The frequency meter should read the spacing frequency ±1 cps of the odd-numbered channel under test (par. 7*c*).

(8) Connect the CARRIER MONITOR jacks of the even-numbered channel to the SPARE AMPL INPUT jacks on the LEVEL CONTROL & PLATE SUPPLY. The frequency meter should now read the spacing frequency ±1 cps of

the even-numbered channel under test (par. 7*c*).

(9) Change the MARK–SPACE–DOT switch to the MARK position. The frequency meter should read the marking frequency ±1 cps of the even-numbered channel under test (par. 7*c*).

(10) Set the transmitter channel levels as follows before returning the equipment to service.

(*a*) Connect the BRIDGING jacks of the LEVEL METER to the CARRIER MONITOR jacks of the odd-numbered channel.

(*b*) Connect the OUTPUT jack of the DOTTER to the odd-numbered loop EQUIP jack of the transmitter.

(*c*) Set the MARK–SPACE–DOT switch to the DOT position. Adjust the odd-numbered channel CARRIER LEVEL control for the correct CARRIER MONITOR level for the channel as recorded in paragraph 96*a*(16) or (18).

(*d*) Connect the BRIDGING jacks of the LEVEL METER to the CARRIER MONITOR jacks of the even-numbered channel.

(*e*) Repeat the procedure in (*c*) above for the even-numbered channel.

(11) Disconnect all test equipment from the transmitter and LEVEL CONTROL & PLATE SUPPLY. Restore all transmitter controls to their normal positions and adjust loop currents to their normal values before returning the transmitter to service.

## 259. Transmitter, Troubleshooting Chart

(figs. 171 and 172)

The following chart is supplied as an aid in locating trouble in the transmitter. This chart lists the symptoms which may be observed when sectionalizing trouble in Telegraph Terminal AN/FGC–29. The chart also lists the probable cause of the symptom and gives the localization and isolation procedures to be used to find the trouble and correct it. After the trouble has been localized to a subassembly or circuit in the odd- or even-numbered channel of the transmitter, trouble isolation tests (pars. 261–263) or voltage and resistance measurements (par. 266) should be sufficient to locate the trouble. Tuned network tests for these sealed units are discussed in paragraphs 264 and 265, respectively. If the trouble-shooting chart indicates the specific subassembly or circuit in which the trouble is likely to be found, trouble localization or isolation should begin with the test indicated by the paragraph reference in the correction column. Otherwise the trouble localization procedures should begin with the first procedure given in paragraph 260*b*.

| Symptom | Probable trouble | Correction |
|---|---|---|
| 1. No carrier output from both even and odd channel of transmitter. | Failure of ac power supply. | Check ac power source. Check power cord and connectors. Check for presence of 230 v ac between terminals 1 and 4 of transformer T2 of bias supply PS1 and PS2. Check fuses F3 and F4 and indicator lamps I 3 and I 4. |
| | Failure of B-plus voltage. | Check for presence of +200 v dc between terminal 14 of terminal board TB 3 on keyer Y1 or Y2 and ground. If absent, check fuse F2, indicator lamp I 2, and power circuit continuity including wiring to LEVEL CONTROL & PLATE SUPPLY. |
| 2. No carrier output from odd channel of transmitter. | Failure of heater voltage. | Check for presence of 6.3 v ac between terminals 1 and 2 of terminal board TB5 on bias supply PS1. If present, check heater circuit continuity. If absent, perform trouble isolation tests for bias supply PS1 (par. 262). |
| | Faulty IDLE–NORMAL switch S3. | Check contacts of IDLE–NORMAL switch S3. |
| | Failure of keyer Y1. | Perform trouble isolation tests of keyer Y1 (par. 261). |
| | Failure of oscillator tuner Z1. | Perform trouble isolation tests of oscillator tuner Z1 (par. 263). |
| | Defective transmitter filter FL1. | Perform the tests on transmitter filter FL1 (par. 265). |
| | Defective CARRIER OUTPUT jacks. | Check jack J1 and wiring from transmitter filter FL1, terminal 1 to jack J1 and from jack J1 to terminal J of connector J16. |

| Symptom | Probable trouble | Correction |
|---|---|---|
| 3. No frequency-shift signal from odd channel of transmitter. | Defective DIVERSITY switch S5. | Check contacts of DIVERSITY switch S5. |
| | Failure of fuse F1 | Check fuse F1 and indicator I 1. |
| | Defective jack or wiring in odd channel jack group. | Check jacks and wiring to jacks J9 and J10, and check connections from terminal A of connector J16 to jack group and from jack group through LOOP CURRENT ADJUST resistor R21 to terminal 11 of terminal board TB3 in keyer Y1. |
| | Failure of loop battery voltage. | Check for presence of −130 v dc at terminal 4 of terminal board TB3 of keyer Y1. If absent, check wiring from terminal C of connector J16 to terminal 4 of terminal board TB3 in keyer Y1 and intercabinet wiring to LOOP BATTERY PANEL. |
| | Failure of keyer Y1 | Perform trouble isolation tests for keyer Y1 (par. 261). |
| 4. No carrier output from even channel of transmitter. | Failure of heater voltage | Check for presence of 6.3 v ac between terminals 1 and 2 of terminal board TB5 of bias supply PS2. If present, check heater circuit continuity. If absent performe trouble isolation tests for bias supply PS2 (par. 262). |
| | Defective IDLE-NORMAL switch S4. | Check contacts of IDLE-NORMAL switch S4. |
| | Failure of keyer Y2 | Perform trouble isolation tests of keyer Y2 (par. 261). |
| | Failure of oscillator tuner Z2. | Perform trouble isolation tests of oscillator tuner Z2 (par. 263). |
| | Defective transmitter filter FL2. | Perform the filter tests on transmitter filter FL2 (par. 265). |
| | Defective CARRIER OUTPUT jacks. | Check jack J5 and wiring from transmitter filter FL2 terminal 1 to jack J5 and from jack J5 to terminal K of connector J16. |
| 5. No frequency-shift signal from even channel of transmitter. | Defective DIVERSITY switch S5. | Check contacts of DIVERSITY switch S5. Replace if necessary. |
| | Failure of Fuse F5 | Check fuse F5 and indicator I 5. |
| | Defective jack or wiring in even-channel jack group. | Check jacks and wiring to jacks J12 and J13, and check connections from terminal B of connector J16 to jack group and from jack group through LOOP CURRENT ADJUST resistor R22 to terminal 11 of terminal board TB3 on keyer Y2. |
| | Failure of loop battery voltage. | Check for presence of −130 v dc at terminal D of connector J16. If present, check wiring from terminal D of connector J16 to terminal 4 of terminal board TB3 of keyer Y2. If absent, check intercabinet wiring to LOOP BATTERY PANEL. |
| | Failure of keyer Y2 | Perform trouble isolation tests of keyer Y2 (par. 261). |
| 6. Wrong frequency or level from odd channel of transmitter. | Transmitter misalined | Perform alinement of transmitter (par. 96). |
| | Failure of keyer Y1 | Perform trouble isolation tests of keyer Y1 (par. 261). |
| | Failure of bias supply PS1 | Perform trouble isolation tests of bias supply PS1 (par. 262). |
| | Failure of oscillator tuner Z1. | Perform trouble isolation tests of oscillator tuner Z1 (par. 263). |
| | Faulty transmitter filter FL1. | Perform filter tests on the transmitter filter FL1 (par. 265). |

| Symptom | Probable trouble | Correction |
|---|---|---|
| 7. Wrong frequency or level from even channel of transmitter. | Transmitter misalined | Perform alinement of transmitter (par. 96). |
| | Failure of keyer Y2 | Perform trouble isolation tests of keyer Y2 (par. 261). |
| | Failure of bias supply PS2 | Perform trouble isolation tests of bias supply PS2 (par. 262). |
| | Failure of oscillator tuner Z2. | Perform trouble isolation tests of oscillator tuner Z2 (par. 263). |
| | Faulty transmitter filter FL2. | Perform tests on transmitter filter FL2 (par. 265). |

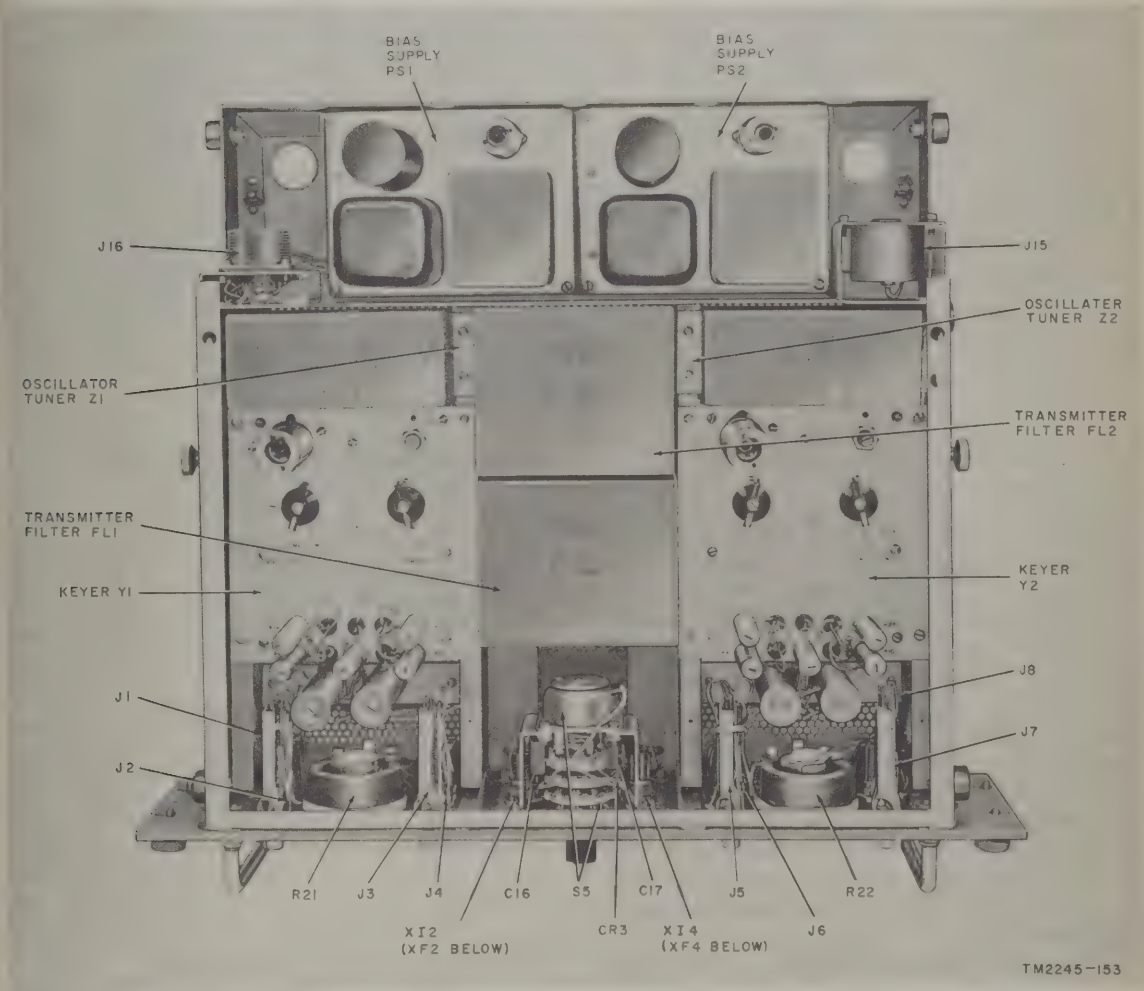



*Figure 171. Transmitter, top view.*

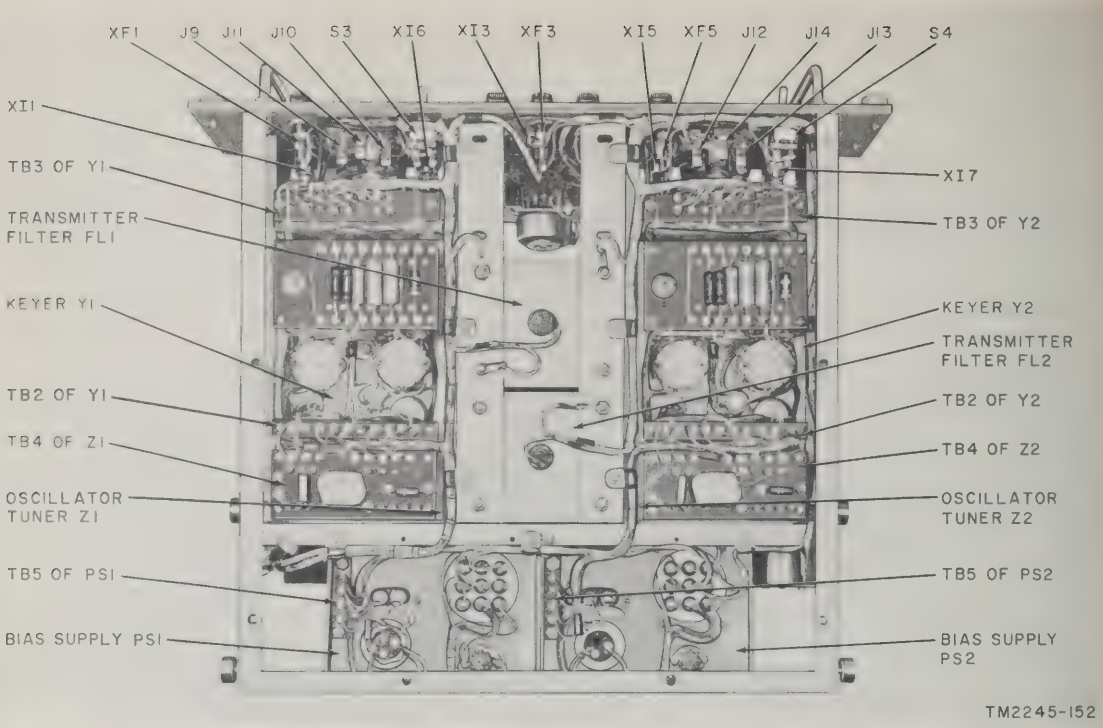



*Figure 172. Transmitter, bottom view.*

## 260. Trouble Localization, Transmitter

(figs. 171 and 172)

The general procedure for localizing trouble is described in paragraph 239*c*. To trace trouble in the transmitter it is necessary to test the even- or odd-numbered channel or both. Check also the circuit wiring from the multicontact connector J16 to the LOOP jacks and the CHANNEL OUTPUT jacks. Trace the dc signal path and the ac signal path in the channel under test on the transmitter schematic diagram (fig. 254). To check the actual wiring, refer to the transmitter wiring diagram (fig. 268).

*a. Test Setup, Transmitter.* Make the test setup indicated below to locate trouble in either the odd-numbered or even-numbered channel of the transmitter.

(1) Set the IDLE–NORMAL switch of the channel being tested to the NORMAL position and the DIVERSITY switch to the 2 CHANNEL LOOPS 1 and 2 position.

(2) Set the LOOP TERMINATION switch in the NEG position.

(3) Set the LOOP CURRENT SELECTOR switch in the 60 MA position.

(4) Connect the OUTPUT jack of the DOTTER to the transmitter EQUIP jack.

(5) Connect the INPUT jack of the LOOP CURRENT METER on the TRANSMITTER METER PANEL to the METER jack of the DOTTER on the same panel.

(6) Set the MARK–SPACE–DOT switch to the MARK position and adjust the LOOP CURRENT ADJUST control of the transmitter until the LOOP CURRENT METER reads 60 ma.

(7) Do not change the S–M EQUALIZER (fig. 46) and the CARRIER LEVEL (fig. 45) controls of the transmitter.

*b. Localization Tests, Transmitter.*

(1) Measure the output level of the transmitter by connecting the CHANNEL OUTPUT jacks to the TERMINATING jacks of the LEVEL METER in the TRANSMITTER METER PANEL. The reading should be $-14$ dbm $\pm 3$ db.

If the reading differs widely from this value proceed with the localization measurements listed in the chart below for 60 ma. loop current.

(2) Turn the MARK–SPACE–DOT switch to the SPACE position and repeat the procedure in (1) above. Reset the DOTTER switch to the MARK position.

(3) Set the LOOP CURRENT SELECTOR switch in the 20 MA position. Adjust the LOOP CURRENT ADJUST control until the LOOP CURRENT METER reads 20 ma.

(4) Measure the output level of the transmitter at the CHANNEL OUTPUT jacks. The reading of the LEVEL METER should be −14 dbm ±3 dbm. If the reading differs widely from the value proceed with the localization measurements listed in the chart below for 20 ma loop current.

(5) Turn the MARK–SPACE–DOT switch to the SPACE position and repeat the procedure in (4) above.

*Note.* In the following table reference symbols for the even-numbered channel are given in the corrective measures column in parentheses following those for the odd-numbered channel.

| Test No. | Test meter | Meter connections | Normal reading | | Corrective measures |
|---|---|---|---|---|---|
| | | | Mark | Space | |
| 1 | Multimeter TS–352/U. | Terminal board TB3 of keyer Y1 or Y2, terminal 11 and ground. | −57 v dc (60 ma loop).<br>−98 v dc (20 ma loop). | 0 (60 ma loop).<br>0 (20 ma loop). | Check wiring to jack J9 (J12) J10 (J13), and J11 (J14). Check LOOP CURRENT ADJUST resistor R21 (R22). |
| 2 | Multimeter TS–352/U. | Terminal board TB3 of keyer Y1 or Y2, terminal 1 and ground. | −21 v dc | −18 v dc | Perform trouble isolation tests for keyer Y1 (Y2) (par. 261), oscillator tuner Z1 (Z2) (par. 263), and bias supply PS1 (PS2) (par. 262). |
| 3 | Electronic Multimeter ME–6A/U. | Terminal board TB3 of keyer Y1 or Y2, terminal 13 and ground. | 97 v ac | 97 v ac | Replace tube V1 in keyer Y1 (Y2). Check connections between terminal board TB2 of keyer Y1 (Y2) and terminal board TB4 of oscillator tuner Z1 (Z2). Perform trouble isolation tests on keyer Y1 (Y2) (par. 261) and oscillator tuner Z1 (Z2) (par. 263). |
| 4 | Electronic Multimeter ME–6A/U. | Transmitter filter FL1 or FL2, terminal 1 and 2 (ground). | 16 v ac | 16 v ac | Check wiring from terminal 13 on terminal board TB3 of keyer Y1 (Y2) to terminal 3 of transmitter filter FL1 (FL2) Also from terminal 1 of transmitter filter FL1 (FL2) to CHANNEL OUTPUT jack J1 (J5). Perform test for transmitter filter (par. 265). |

## 261. Trouble Isolation, Transmitter, Keyer Y1 or Y2

(figs. 173, 174, and 175)

The general procedure to be followed in isolating trouble is discussed in paragraph 239*d*.

*a. Test Setup.* The test setup for isolating trouble in keyer Y1 or Y2 is the same as that used for localizing trouble in the odd- or even-numbered channel of the transmitter (par. 260*b*). Usually, the trouble isolation tests are made immediately following the localization tests, with the test setup left intact.

*b. Isolation Tests, Keyer Y1 or Y2.* To isolate trouble in keyer Y1 or Y2 make the test listed in (1) and (2) below. The tests in (1) below are made with the transmitter controls set as indicated in paragraph 260*a*. The conditions are the same for the tests in (2) below except that the LOOP

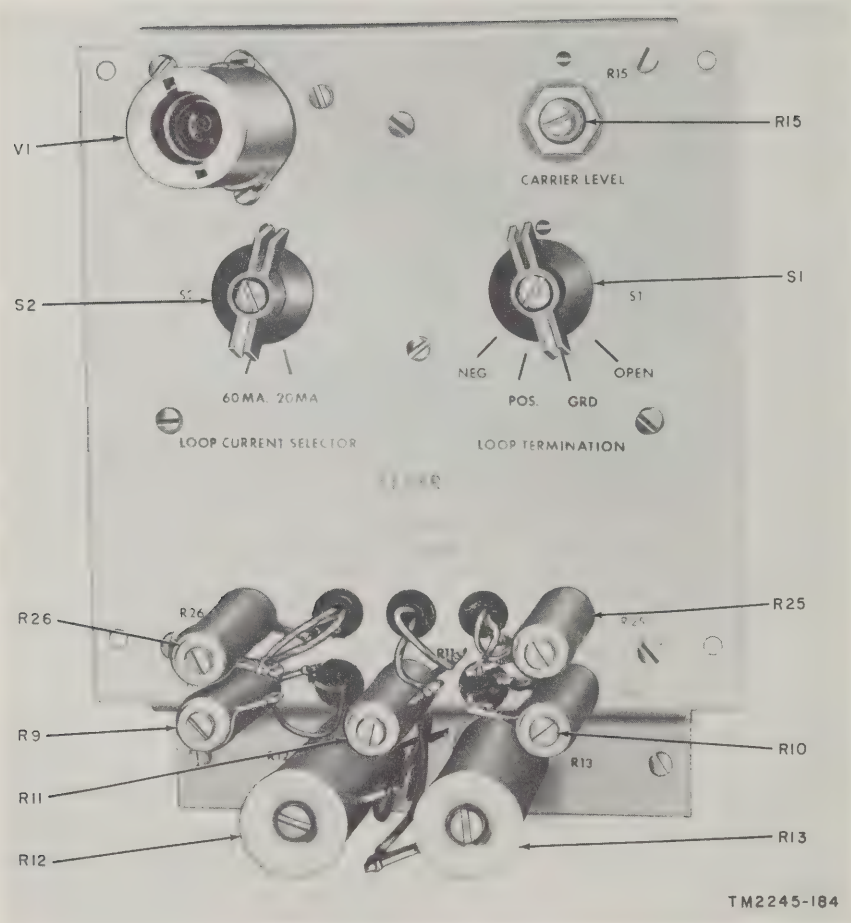



*Figure 173. Keyer, top view.*

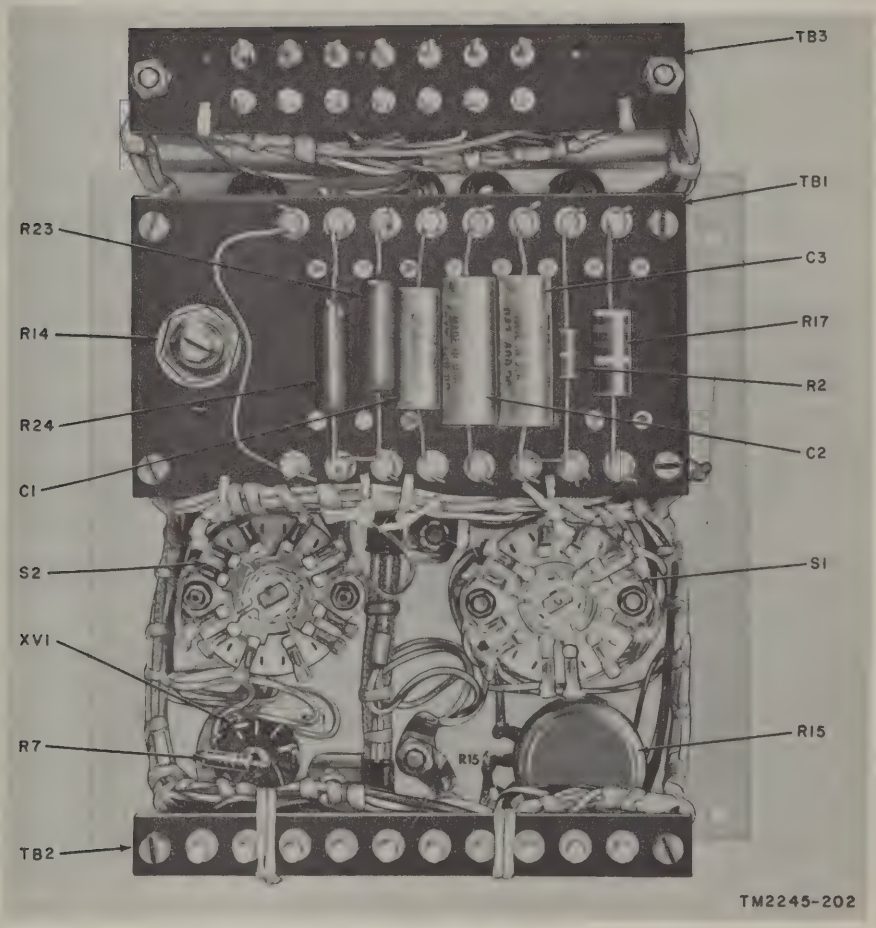



*Figure 174. Keyer, bottom view.*

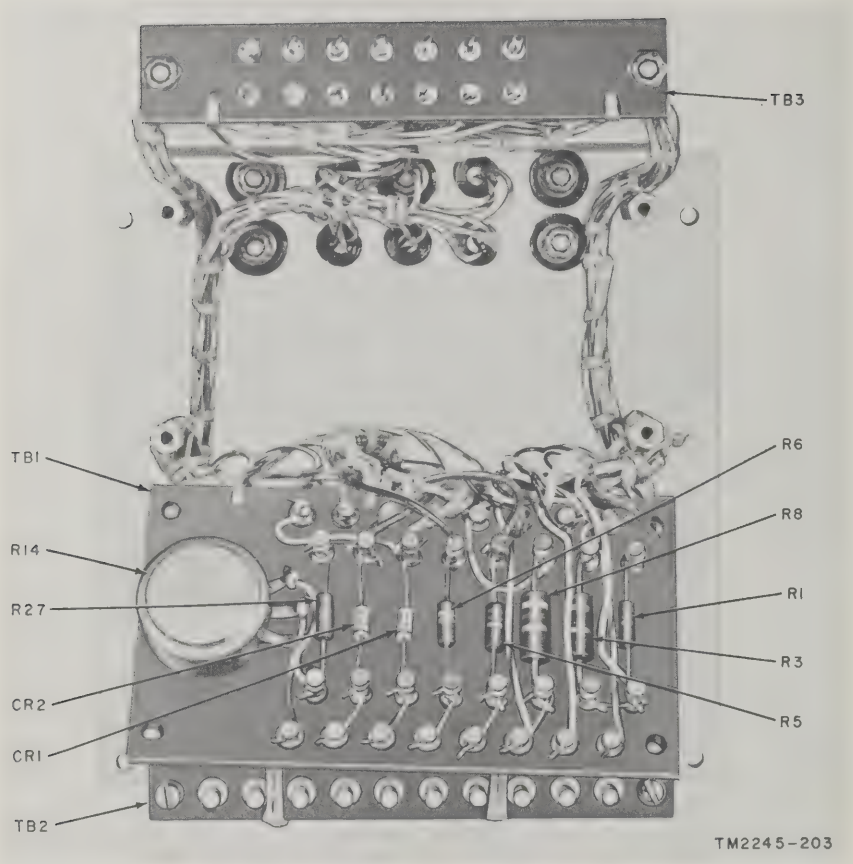



*Figure 175. Keyer, rear of terminal board TB1.*

CURRENT SELECTOR switch is set to the 20 MA position and the loop current adjusted for 20 ma. At the same time, trace the dc signal path and ac signal path on the keyer schematic diagram (fig. 81). To check the actual wiring refer to the wiring diagram of keyer Y1 or Y2 (fig. 269).

*Note.* In the following table, reference symbols for the even-numbered channel are given in the corrective measures column in parentheses following those for the odd-numbered channel.

(1) 60=Ma test.

| Test | Test meter | Meter connections | Normal reading (volts) | | Corrective measures |
|---|---|---|---|---|---|
| | | | Mark | Space | |
| 1 | Multimeter TS–352/U. | Terminal board TB3, terminal 9 and ground. | −57 dc | 0 | Check switch S1, section 2. |
| 2 | Multimeter TS–352/U. | Terminal board TB3, terminal 10 and ground. | −57 dc | 0 | Check MONITOR jack J11 (J14) and wiring between jack and terminal board TB3 of keyer Y1 (Y2). |
| 3 | Multimeter TS–352/U. | Terminal board TB3, terminal 7 and ground. | −57 dc | 0 | Check switch S2. |
| 4 | Multimeter TS–352/U. | Terminal board TB3, terminal 6 and ground. | −57 dc | 0 | Check DIVERSITY switch S5, section 3B (2B). |
| 5 | Multimeter TS–352/U. | Terminal board TB3, terminal 8 and ground. | −29 dc | 0 | Check switch S2 and resistor R12. |
| 6 | Multimeter TS–352/U. | Junction of resistors R10 and R13. | −29 dc | 0 | Check switch S2 and resistor R25. |
| 7 | Multimeter TS–352/U. | Terminal board TB3, terminals 3 or 5 and ground. | 0 | 0 | Check switch S1, section 2 or switch S5, section 2A (even channel only). |
| 8 | Multimeter TS–352/U. | Terminal board TB1, terminal 4 and ground (junction of resistors R23 and R24). | −23 dc | 0 | Check resistor R25, diodes CR1 and CR2 and switch S1, section 1. |
| 9 | Multimeter TS–352/U. | Terminal board TB2, terminal 3 or 4, and ground. | −21 dc | −18 dc | Check resistors R9, R14, R17, R23, R24 and R27 and oscillator tuner Z1 (Z2) (par. 263). Check bias supply PS1 (PS2) (par. 262). |
| 10 | Multimeter TS–352/U. | Tube socket XV1 terminal 6 and ground. | +51 dc | +51 dc | Check resistors R5, R6, R8, R15 and capacitors C1, C2, and C3. Check tube V1. Make voltage and resistance measurement at tube socket XV1 (par. 266). |
| 11 | Electronic Multimeter ME–6A/U. | Terminal board TB3, terminal 13, and ground. | 97 ac | 97 ac | Make voltage and resistance measurements at the tube socket XV1 (par. 266). Check tube V1 and transmitter filter FL1 (FL2) (par. 265). |

(2) *20-ma test.*

| Test No. | Test meter | Meter connections | Normal reading (volts) | | Corrective measures |
|---|---|---|---|---|---|
| | | | Mark | Space | |
| 1 | Multimeter TS–352/U. | Terminal board TB3, terminal 9 and ground. | −98 dc | 0 | Check switch S1, section 2. |
| 2 | Multimeter TS–352/U. | Terminal board TB3, terminal 10 and ground. | −98 dc | 0 | Check MONITOR jack J11 (J14) and wiring between jack and terminal board TB3 of keyer Y1 (Y2). |

| Test No. | Test meter | Meter connections | Normal reading (volts) | | Corrective measures |
|---|---|---|---|---|---|
| | | | Mark | Space | |
| 3 | Multimeter TS–352/U. | Terminal board TB3, terminal 7 and ground. | −44 dc | 0 | Check switch S2 and resistor R11. |
| 4 | Multimeter TS–352/U. | Terminal board TB3, terminal 6 and ground. | −44 dc | 0 | Check DIVERSITY switch S5, section 3B (2B). |
| 5 | Multimeter TS–352/U. | Terminal board TB3, terminal 8 and ground. | −22 dc | 0 | Check switch S2 and resistor R26. |
| 6 | Multimeter TS–352/U. | Junction of resistors R10 and R13. | −6.7 | 0 | Check switch S2 and resistors R10 and R13. |
| 7 | Multimeter TS–352/U. | Terminal board TB3, terminals 3 or 5 and ground. | 0 | 0 | Check switch S1, section 2 or switch S5, section 2A (even channel only). |
| 8 | Multimeter TS–352/U. | Terminal board TB1, terminal 4 and ground (junction of resistors R23 and R24). | −22 dc | 0 | Check switch S1, section 1, and diodes CR1 and CR2. |
| 9 | Multimeter TS–352/U. | Terminal board TB2, terminal 3 or 4 and ground. | −21 dc | −18 dc | Check resistors R9, R14, R17, R23, R24 and R27 and oscillator tuner Z1 (Z2) (par. 263). Check bias supply PS1 (PS2) (par. 262). |
| 10 | Multimeter TS–352/U. | Tube socket XVI, terminal 6 and ground. | +51 dc | +51 dc | Check resistors R5, R6, R8, R15, and capacitors C1, C2, and C3. Check tube V1. Make voltage and resistance measurements at tube socket XVI (par. 266). |
| 11 | Electronic Multimeter ME–6A/U. | Terminal board TB3, terminal 13 and ground. | 97 ac | 97 ac | Make voltage and resistance measurements at tube socket XVI (par. 266). Check tube V1 and transmitter filter FL1 (FL2) (par. 265). |

## 262. Trouble Isolation, Transmitter, Bias Supply PS1 or PS2

(figs. 176 and 177)

The general procedure to be followed in isolating trouble is discussed in paragraph 239*d*.

*a. Test Setup.* The test setup for isolating trouble in bias supply PS1 or PS2 is the same as that used for localizing trouble in the odd or even channel of the transmitter (par. 260*a*). Usually the trouble isolation procedures are performed immediately following the localization tests and with the test setup left intact.

*b. Isolation Tests, Bias Supply PS1 or PS2.* To isolate trouble in bias supply PS1 or PS2 make the tests listed in the chart below. Refer to the schematic diagram of the bias supply (fig. 84). To check the actual wiring, refer to the wiring diagram of the bias supply (fig. 271).

| Test No. | Multimeter TS–352/U connections | Normal reading (volts) | Corrective measures |
|---|---|---|---|
| 1 | Transformer T2, terminals 7 and 8 and terminals 8 and 9. | 90 ac | Check transformer T2 (par. 266*a* (2)). |
| 2 | Terminal board TB5, terminals 1 and 2 | 6.3 ac | Check transformer T2 (par. 266*a* (2)). |
| 3 | Terminal board TB5, terminals 3 (+) and and 4 (−). | 35 dc | Check tube V3. Check inductor L1, capacitor C15, and resistor R20. |

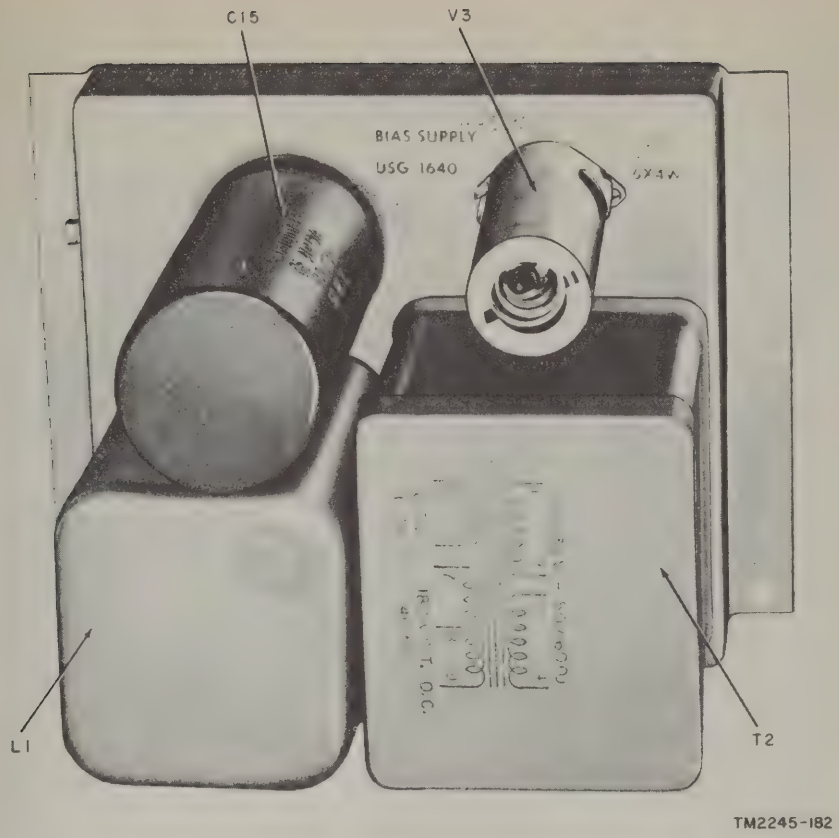



*Figure 176. Bias supply, top view.*

## 263. Trouble Isolation, Transmitter, Oscillator Tuner Z1 or Z2

(figs. 178 and 179)

The general procedure to be followed in isolating trouble is discussed in paragraph 239*d*.

*a. Test Setup.* The test setup for isolating trouble in oscillator tuner Z1 or Z2 of the transmitter is the same as that used for localizing the trouble in either the odd-numbered or even-numbered channel of the transmitter (par. 260*a*). Usually the trouble isolation tests are made immediately following the localization tests with the test setup left intact.

*b. Isolation Tests, Oscillator Tuner Z1 or Z2.* To isolate trouble in the oscillator tuner, make the measurements listed in the chart below. Refer to the schematic diagram of the oscillator tuner (fig. 82). To check the actual wiring, refer to the wiring diagram of the oscillator tuner (fig. 270).

| Test No. | Test meter | Meter connections | Normal reading (volts) | | Corrective measures |
|---|---|---|---|---|---|
| | | | Mark | Space | |
| 1 | Multimeter TS–352/U | Terminal board TB4, terminals 12, 15, and 19 to ground. | −21 dc | −18 dc | Check tuned network Z3 (par. 264). |
| 2 | Electronic Multimeter ME–6A/U | Terminal board TB4, terminals 5 and 8 to ground. | 11 ac | 11 ac | Check capacitors C7 through C14 and resistor R18. Check tuned network Z3 (par. 264). |

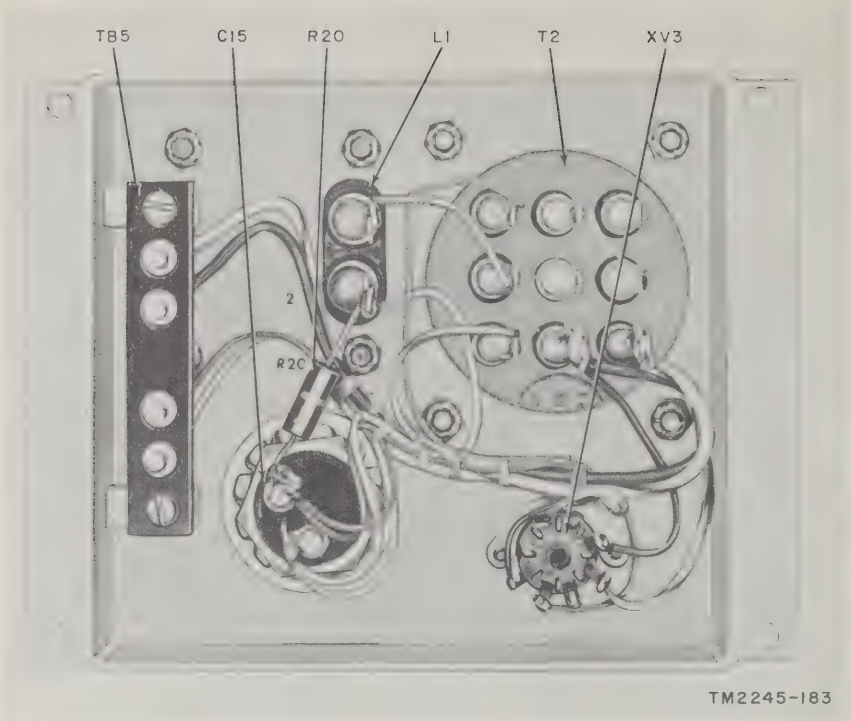



*Figure 177. Bias supply, bottom view.*

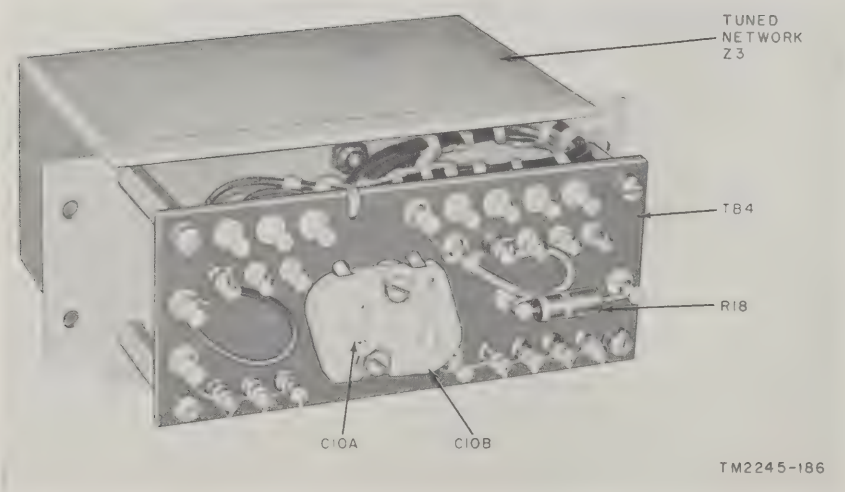



*Figure 178. Oscillator tuner, bottom view.*

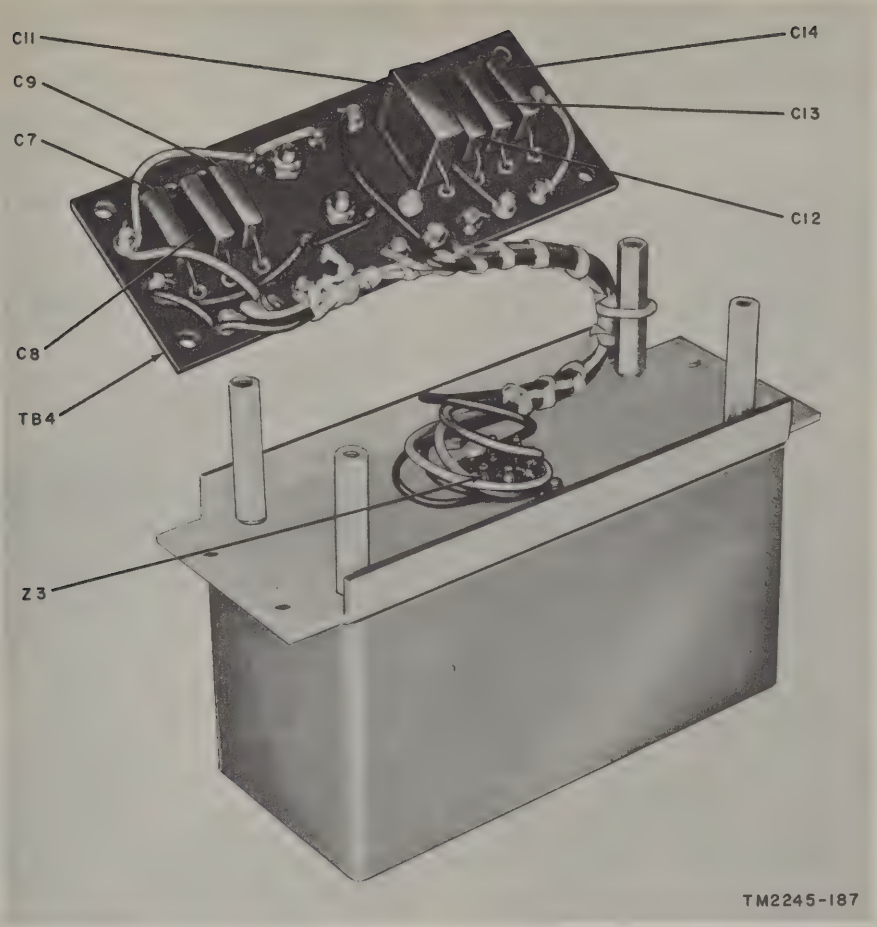



*Figure 179. Oscillator tuner, bottom view with terminal board TB4 removed and rotated.*

## 264. Transmitter, Tuned Network Tests

Tuned networks Z3 are nonrepairable sealed units which must be replaced if found to be defective. Test the tuned networks in place in the equipment as installed. It is assumed that the remaining circuits of the transmitter are in normal operating condition. Measure the resistance of the tuned network with the leads disconnected from the unit (par. 247).

*a. Test Equipment Required.* The test equipment required for testing the tuned network consists of Frequency Meter FR–67/U or Frequency Counter AN/USM–26, and Electronic Multimeter ME–6A/U. The LEVEL CONTROL & PLATE SUPPLY provides an amplifier to amplify the transmitter signals for frequency measurement, and the LOOP CURRENT METER is used to measure and adjust the loop current; these are on the TRANSMITTER METER PANEL. The frequency meter accurately measures the oscillator frequency, and the electronic multimeter measures the oscillator voltage.

*b. Connections.* Test the tuned network in its normal position in the oscillator tuner of the transmitter channel. Make the connections for testing the tuned network as described in (1) through (8) below.

(1) Set DIVERSITY switch S5 to the 2 CHANNEL position.

(2) Set LOOP CURRENT SELECTOR switch S2 to the 60 MA position.

(3) Set LOOP TERMINATION switch S1 to the GRD position.

(4) Set CARRIER LEVEL control (R15) to the extreme clockwise position.

(5) Connect the CARRIER MONITOR jacks of the TRANSMITTER to the SPARE AMPL INPUT jacks of the LEVEL CONTROL & PLATE SUPPLY.

(6) Connect the frequency meter to the SPARE AMPL OUTPUT jacks of the LEVEL CONTROL & PLATE SUPPLY.

(7) Place the external loop circuit in the marking condition (closed to ground).

(8) Connect the INPUT jack of the LOOP CURRENT METER to the loop MONITOR jack of the transmitter channel, and adjust the associated LOOP CURRENT ADJUST control for a meter reading of 60 ma.

*c. Measurements.* Use the procedures given in (1) and (2) below to make the test measurements of the tuned network.

(1) With the external loop in the marking (closed) condition check to see that the marking frequency as read on the frequency meter is the same as that indicated in *d* below for the particular tuned network channel.

(2) With the external loop in the spacing condition check to see that the spacing frequency is the same as that indicated in *d* below for the particular tuned network channel.

(3) If the frequency is outside limits, realign the transmitter (par. 96). If the space and mark frequencies cannot be brought within limits, replace the tuned network.

*d. Frequencies, Tuned Network Tests.* The test frequencies for the tuned network are listed below.

| Tuned network designation | Test frequency (cps) | |
|---|---|---|
| | Space | Mark |
| 1/16 | 1, 742. 5±1 | 1, 827. 5±1 |
| 2/15 | 2, 932. 5±1 | 3, 017. 5±1 |
| 3/14 | 1, 912. 5±1 | 1, 997. 5±1 |
| 4/13 | 2, 762. 5±1 | 2, 847. 5±1 |
| 5/12 | 2, 082. 5±1 | 2, 167. 5±1 |
| 6/11 | 2, 592. 5±1 | 2, 677. 5±1 |
| 7/10 | 2, 252. 5±1 | 2, 337. 5±1 |
| 8/9 | 2, 422. 5±1 | 2, 507. 5±1 |

## 265. Transmitter, Filter Tests

(fig. 180)

Transmitter filters FL1 and FL2 are nonrepairable sealed units which must be replaced if found to be defective. Test these filters by measuring the transmission characteristics of each filter at specified frequencies (*d* below) with the filter removed from the transmitter circuit. Measure also the resistance between the filter terminals. The following subparagraphs list the test equipment required for filter testing, describe the test setup, give instructions for making filter measurements, and list the normal readings for filter tests and, the center frequencies for the filters.

*a. Test Equipment Required.* The test equipment required for filter testing consists of Signal Generator SG–15/PCM, Frequency Meter FR–67/U or Frequency Counter AN/USM–26, and Electronic Multimeter ME–6A/U. The signal generator provides the input signal for the filter under test, and the frequency meter provides accurate measurement of the test frequency. The electronic multimeter measures the input and output voltages.

*b. Connections.* The transmitter filters require a 600-ohm resistor to match terminals 1 and 2 and a 7,500-ohm resistor to match terminals 3 and 4. Make the connections for testing the transmitter filters as shown in figure 180 and described in (1) through (5) below.

(1) Connect one output terminal of the signal generator to terminal 1 of the transmitter filter under test through a 600-ohm, ½-watt resistor.

(2) Connect the second output terminal of the signal generator to terminal 2 of the filter.

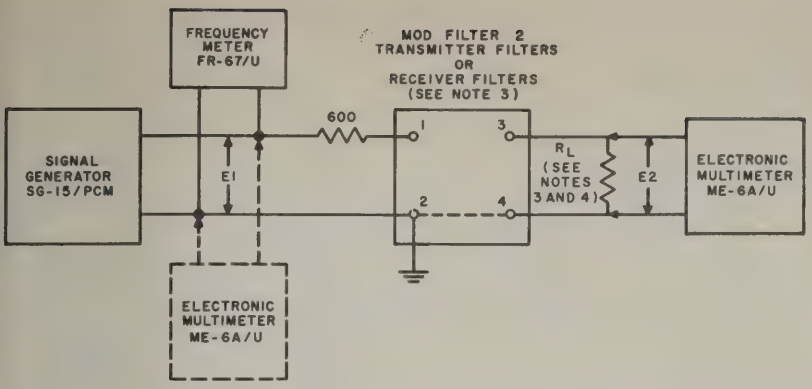
(3) Connect terminal 2 of the filter to ground.

(4) Connect the input leads of the frequency meter to the output terminals of the signal generator.

(5) Connect a 7,500-ohm, ½-watt resistor between terminals 3 and 4 of the filter.

*c. Measurements.* Each transmitter filter is tested ((1) through (6) below) at its center frequency (*e* below) and at frequencies of 45 cps and 115 cps above and below the center frequency.

(1) Connect the electronic multimeter to the output terminals of the signal generator.




NOTES:

1. RESISTORS ARE IN OHMS.
2. ONLY ONE ELECTRONIC MULTIMETER ME-6A/U IS REQUIRED FOR THIS TEST ARRANGEMENT.
3.

| TRANSMITTER FILTERS | | RECEIVER FILTERS | |
|---|---|---|---|
| DESIGNATION | $R_L$ (OHMS) | DESIGNATION | $R_L$ |
| 1/16 | 7,500 | 1/16 | 100K |
| 2/15 | 7,500 | 2/15 | 100K |
| 3/14 | 7,500 | 3/14 | 100K |
| 4/13 | 7,500 | 4/13 | 100K |
| 5/12 | 7,500 | 5/12 | 100K |
| 6/11 | 7,500 | 6/11 | 100K |
| 7/10 | 7,500 | 7/10 | 100K |
| 8/9 | 7,500 | 8/9 | 100K |

4. $R_L$ FOR MOD FILTER IS 10K OHMS.

TM2245-384

*Figure 180. Transmitter and receiver filters, and mod filter 2, test arrangement.*

(2) Adjust the output frequency of the signal generator to the frequency specified for test 1 in *d* below as measured on the frequency counter.

(3) Adjust the signal generator output voltage to exactly the voltage E1 specified in *d* below.

(4) Disconnect the electronic multimeter from the signal generator and connect it between terminals 3 and 4 of the filter.

(5) Measure the filter output voltage (voltage E2 in *d* below).

(6) Repeat the procedure given in (1) through (5) above for each frequency listed in the table in *d* below for the particular transmitter filter.

*d. Normal Readings, Transmitter Filters.* The transmitter filters are acceptable for use if voltage readings E2 in tests 1 through 5 in the table below fall within the limits indicated.

| Test | Test frequency (cps) | E1 (volts) | E2 (volts) |
|---|---|---|---|
| 1 | Center frequency minus 115 cps. | 0.775 | 0.0245 max |
| 2 | Center frequency minus 45 cps. | .775 | .65 min |
| 3 | Center frequency | .775 | .775 min |
| 4 | Center frequency plus 45 cps. | .775 | .65 min |
| 5 | Center frequency plus 115 cps. | .775 | .0245 max |

*e. Center Frequencies, Transmitter Filters.* The center frequency of each transmitter filter is indicated below.

| Transmitter filter designation | Center frequency (cps) |
|---|---|
| 1/16 | 1,785 |
| 3/14 | 1,955 |
| 5/12 | 2,125 |
| 7/10 | 2,295 |
| 8/9 | 2,465 |
| 6/11 | 2,635 |
| 4/13 | 2,805 |
| 2/15 | 2,975 |

## 266. Additional Troubleshooting Information, Transmitter

*a. Typical Resistance Readings.* Measure the resistance of transformers, tuners, filters and solenoids with all connections removed from their terminals. Measure the resistances at the terminals of tube sockets with the connections intact and all conditions normal except that the power is disconnected from the component. Typical resistance measurements for subassemblies of the transmitter are given in (1) through (4) below.

(1) *Keyer Y1 or Y2.*

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Tube socket XVI | 3 | Ground | 6,000 |
| | 7 | Ground | 470,000 |
| | 8 | Ground | 1,000 |

(2) *Bias supply PS1 or PS2.*

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Transformer T2 | 1 | 4 | 160 |
| | 5 | 6 | .45 |
| | 7 | 8 | 160 |
| | 8 | 9 | 150 |
| Inductor L1 | 1 | 2 | 230 |

(3) *Tuned network Z3.*

| Tuned network designation | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| 1/16 | 1 | 2 | 22 |
| | 2 | 3 | 22 |
| | 4 | 5 | 33 |
| | 5 | 6 | 33 |
| 2/15 | 1 | 2 | 18 |
| | 2 | 3 | 18 |
| | 4 | 5 | 36 |
| | 5 | 6 | 36 |
| 3/14 | 1 | 2 | 22 |
| | 2 | 3 | 22 |
| | 4 | 5 | 33 |
| | 5 | 6 | 33 |
| 4/13 | 1 | 2 | 18 |
| | 2 | 3 | 18 |
| | 4 | 5 | 36 |
| | 5 | 6 | 36 |
| 5/12 | 1 | 2 | 18 |
| | 2 | 3 | 18 |
| | 4 | 5 | 24 |
| | 5 | 6 | 24 |
| 6/11 | 1 | 2 | 18 |
| | 2 | 3 | 18 |
| | 4 | 5 | 36 |
| | 5 | 6 | 36 |
| 7/10 | 1 | 2 | 9.9 |
| | 2 | 3 | 9.9 |
| | 4 | 5 | 24 |
| | 5 | 6 | 24 |
| 8/9 | 1 | 2 | 9.9 |
| | 2 | 3 | 9.9 |
| | 4 | 5 | 24 |
| | 5 | 6 | 24 |

(4) *Transmitter filter FL1 or FL2.*

| Filter designation | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| 1/16 | 1 | 3 | Infinite |
| | 1 | 2 | Infinite |
| | 3 | 4 | 10 |
| | 2 | 4 | 0 |
| 2/15 | 1 | 3 | Infinite |
| | 1 | 2 | Infinite |
| | 3 | 4 | 3.7 |
| | 2 | 4 | 0 |
| 3/14 | 1 | 3 | Infinite |
| | 1 | 2 | Infinite |
| | 3 | 4 | 8.9 |
| | 2 | 4 | 0 |
| 4/13 | 1 | 3 | Infinite |
| | 1 | 2 | Infinite |
| | 3 | 4 | 4 |
| | 2 | 4 | 0 |
| 5/12 | 1 | 3 | Infinite |
| | 1 | 2 | Infinite |
| | 3 | 4 | 6.7 |
| | 2 | 4 | 0 |
| 6/11 | 1 | 3 | Infinite |
| | 1 | 2 | Infinite |
| | 3 | 4 | 4.3 |
| | 2 | 4 | 0 |
| 7/10 | 1 | 3 | Infinite |
| | 1 | 2 | Infinite |
| | 3 | 4 | 6.1 |
| | 2 | 4 | 0 |
| 8/9 | 1 | 3 | Infinite |
| | 1 | 2 | Infinite |
| | 3 | 4 | 5.6 |
| | 2 | 4 | 0 |

(5) *Rotary type solenoid (S5).*

| Item | Measure | Resistance (ohms) |
|---|---|---|
| Solenoid S5 | Between leads of solenoid winding | 190 |

*b. Typical Voltage Readings.* Voltages are measured with the component connected to its regular power supply, with tubes in place and all conditions normal. Typical voltage readings

for subassemblies of the transmitter are given in (1) and (2) below.

(1) *Keyer Y1 or Y2.*

| Item | Measure from terminal | Measure to terminal | Voltage (volts) |
|---|---|---|---|
| Tube socket XV1 | 1 | Ground | +200 dc |
| | 3 | Ground | +10 dc |
| | 4, 5 | 9 | 6.3 ac |
| | 6 | Ground | +51 dc |
| | 8 | Ground | +1 dc |

(2) *Bias supply PS1 or PS2.*

| Item | Measure from terminal | Measure to terminal | Voltage (volts) |
|---|---|---|---|
| Transformer T2 | 1 | 4 | 230 ac |
| | 7 | 8 | 90 ac |
| | 8 | 9 | 90 ac |
| Terminal board TB5 | 5 | 6 | 6.3 ac |
| | 3 (+) | 4 (−) | 35 dc |

## Section VII. TROUBLESHOOTING, SUBGROUP MODULATOR

### 267. Operational Test, SUBGROUP MODULATOR

The general procedure to be followed in making an operational test is described in paragraph 239*b*. To determine whether or not the SUBGROUP MODULATOR is functioning properly it is necessary to check the performance of both the direct path and the translated path.

*a. Test Setup.* The SUBGROUP MODULATOR remains in place connected to its normal power supply as installed. Connect Signal Generator SG–15/PCM, Frequency Meter FR–67/U or Frequency Counter AN/USM–26, and the LEVEL METER on the TRANSMITTER METER PANEL as described in *b*, *c* and *d* below and make the indicated measurements.

*b. Direct Path.* To check the operation of the direct path of the SUBGROUP MODULATOR follow the procedure outlined in (1) through (3) below.

(1) Connect the OUTPUT jacks of Signal Generator SG–15/PCM to the DIRECT PATH INPUT EQUIP jacks of the SUBGROUP MODULATOR, and insert an open twin plug into the TRANSLATED PATH INPUT EQUIP jacks.

(2) Adjust the frequency of the signal generator to 2,400 cps and its output level to +5 dbm.

(3) Connect the TERMINATING jacks of the LEVEL METER on the TRANSMITTER METER PANEL to the OUTPUT EQUIP jacks of the SUBGROUP MODULATOR. The LEVEL METER should read −25 dbm±2 db. Record the exact reading obtained.

*c. Translated Path.* Follow the procedures given in (1) through (3) below to check the performance of the translated path of the SUBGROUP MODULATOR.

(1) Without changing the setting of the signal generator from that of *b*(2) above, connect it to the TRANSLATED PATH INPUT EQUIP jacks, and insert the open twin plug in the DIRECT PATH INPUT EQUIP jacks. The reading should be −25 dbm±2 db and within 1.5 db of the reading obtained in *b*(3) above. Record this reading.

(2) Readjust the frequency of the signal generator to 1,740 cps, maintaining the output level at +5 dbm. The LEVEL METER should show a reading within 2 db of the reading obtained in (1). Record this reading.

(3) Readjust the frequency of the signal generator to 3,020 cps, maintaining the output level at +5 dbm. The LEVEL METER should show a reading within 2 db of the readings obtained in (1) and (2) above.

*d. Frequency Translation Test.* The procedures in (1) through (6) below check that the signals applied to the translated path of the SUBGROUP MODULATOR are properly translated in frequency.

(1) Disconnect the TERMINATING jacks of the LEVEL METER from the OUTPUT EQUIP jacks of the SUBGROUP MODULATOR.

(2) Connect the INPUT jacks of the frequency meter to the TRANSLATED PATH INPUT MONITOR jacks of the SUBGROUP MODULATOR.

(3) Adjust the frequency of the signal generator as closely as possible to 2,400 cps and note the exact frequency indicated by the frequency meter.

(4) Connect the INPUT jacks of the frequency meter to the OUTPUT EQUIP jacks of the LEVEL CONTROL & PLATE SUPPLY (LEVEL ADJUST control on position 35).

(5) The frequency meter should read 3,400 cps minus the reading obtained in (3) above $\pm 1$ cps.

(6) Remove all cords and plugs from the front panels of the SUBGROUP MODULATOR and the LEVEL CONTROL & PLATE SUPPLY. Return the LEVEL ADJUST control on the LEVEL CONTROL & PLATE SUPPLY to its original setting.

## 268. SUBGROUP MODULATOR, Troubleshooting Chart

The following chart is supplied as an aid in locating trouble in the SUBGROUP MODULATOR. This chart lists the symptoms that are observed when sectionalizing Telegraph Terminal AN/FGC–29 for trouble. The chart also lists the probable cause of the symptom and gives the localization and isolation procedures to be used to correct it. After trouble has been localized to a subassembly or circuit in the direct or translated path of the SUBGROUP MODULATOR, trouble isolation tests, or voltage and resistance measurements, should be sufficient to locate the trouble. The trouble isolation tests are given in paragraphs 270 through 273 and filter tests in subparagraph 274. The voltage and resistance measurements are given in tabular form in paragraph 275. If the troubleshooting chart indicates the specific subassembly or circuit in which the trouble is likely to be found, begin trouble localization or isolation with the test indicated by the paragraph reference in the *Correction* column. Otherwise, begin the trouble localization procedures with the first step given in paragraph 269.

| Symptom | Probable trouble | Correction |
|---|---|---|
| 1. No transmission through either direct or translated paths of SUBGROUP MODULATOR. | *a.* Defective jack or wiring in OUTPUT jack group. | *a.* Connect a patching cord between OUTPUT EQUIP jacks and OUTPUT LINE jacks. If this clears trouble, check jacks and wiring of jacks J17 through J22. |
| | *b.* Failure of output coupler Z3. | *b.* Check output coupler Z3 (par. 275*a*(2)). |
| 2. No transmission through direct path of SUBGROUP MODULATOR. | *a.* Failure of output coupler Z3. | *a.* Check output coupler Z3 (par. 275*a*(2)). |
| | *b.* Defective jack or wiring in DIRECT PATH INPUT jack group. | *b.* Connect a patching cord between INPUT BUS and INPUT EQUIP jacks. If this clears trouble, check jacks and wiring of jacks J5 through J10. |
| 3. No transmission through translated path of SUBGROUP MODULATOR. | *a.* Defective jack or wiring in TRANSLATED PATH INPUT jack groups. | *a.* Connect a patching cord between INPUT BUS and INPUT EQUIP jacks. If this clears trouble, check jacks and wiring of jacks J11 through J16. |
| | *b.* Failure of ac power supply. | *b.* Check ac power source. Check power cord and connectors. Check for presence of 230 volts ac between terminals 1 and 4 on transformer T3 of plate supply PS1. If absent check fuses F1 and F2 and indicator lamps I 1 and I 2. |
| | *c.* Failure of B-plus voltage. | *c.* Check for presence of 200 v dc between terminals 1 and 2 on terminal board TB4, of plate supply PS1. If absent, perform trouble isolation tests for plate supply PS1 (par. 273). If present, check power circuit continuity. |
| | *d.* Failure of heater voltage. | *d.* Check for presence of 6.3 v ac between terminals 3 and 5 on terminal board TB4 of plate supply PS1. If absent, perform trouble isolation tests for plate supply PS1 (par. 273). If present, check for heater circuit continuity. |

| Symptom | Probable trouble | Correction |
|---|---|---|
| 3. No transmission through translated path of SUB GROUP MODULATOR. | *e.* Failure of converter Z2 | *e.* Perform trouble isolation tests for converter Z2 (par. 270). |
| | *f.* Failure of mod filter 1 (FL 1). | *f.* Check mod filter 1 (FL1) (par. 274). |
| | *g.* Failure of carrier supply Y1. | *g.* Check for presence of 7.2 v ac between terminals 1 and 2 of terminal board TB5. If absent, perform trouble isolation tests for carrier supply Y1 (par. 272). |
| | *h.* Failure of modulator Z1 | *h.* Perform trouble isolation tests for modulator Z1 (par. 271). |
| | *i.* Failure of mod filter 2 (FL2). | *i.* Check mod filter 2 (par. 274). |
| | *j.* Failure of output coupler Z3. | *j.* Check output coupler Z3 (par. 275*a*(2)). |
| 4. Direct and translated path output level out of limits. | *a.* Defective output coupler Z3. | *a.* Check output coupler Z3 (par. 275*a*(2)). |
| 5. Translated path output level out of limits. | *a.* Defective converter Z2 | *a.* Perform trouble isolation on converter Z2 (par. 270). |
| | *b.* Defective mod filter 1 (FL1) or 2 (FL2). | *b.* Check mod filter 1 (FL1) or 2 (FL2) (par. 274). |
| | *c.* Defective modulator Z1 | *c.* Perform trouble isolation tests for modulator Z1 (par. 271). |
| | *d.* Defective output coupler Z3. | *d.* Check output coupler Z3 (par. 275*a*(2)). |
| 6. Carrier supply output level out of limits. | *a.* Defective part in carrier supply Y1. | *a.* Check GAIN control R53 of carrier supply Y1 (par. 272*b*). Perform trouble isolation tests for carrier supply Y1. |
| | *b.* Defective modulator Z1 | *b.* Perform trouble isolation test on modulator Z1 (par. 271). |
| 7. Carrier supply output frequency out of limits. | *a.* Defective crystal Y1 | *a.* Replace crystal Y1. |
| | *b.* Defective part in carrier supply Y1. | *b.* Perform trouble isolation tests for carrier supply Y1 (par. 272). |
| 8. Excessive carrier leak at modulator output. | *a.* Defective varistor CR1 of modulator Z1. | *a.* Replace varistor CR1. |
| | *b.* Defective part in modulator Z1. | *b.* Perform trouble isolation tests for modulator Z1 (par 271). |
| 9. Converter output level out of limits. | *a.* Defective part in converter Z2. | *a.* Perform trouble isolation tests for converter Z2 (par. 270). |
| 10. Converter output frequency out of limits. | *a.* Defective crystal Y2 | *a.* Replace crystal Y2. |
| | *b.* Defective part in converter. | *b.* Perform trouble isolation test for converter Z2 (par. 270). |

## 269. Trouble Localization, SUBGROUP MODULATOR

(figs. 181 and 182)

The general procedure for localizing trouble is described in paragraph 239*c*. To trace trouble in the SUBGROUP MODULATOR it is necessary to test the direct path, the translated path, or both. Check the circuit wiring from multicontact connector J23 to the DIRECT PATH INPUT BUS jacks, the TRANSLATED PATH INPUT BUS jacks, and the OUTPUT LINE jacks. Use Signal Generator SG–15/PCM as a source of test frequencies and Electronic Multimeter ME–6A/U to measure voltages as indicated in *b* or *d* below. To localize trouble in the direct path, follow the procedures described in *b* and *c* below. To localize trouble in the translated path, follow the procedures given in *d* and *e* below. Use the SUBGROUP MODULATOR schematic diagram (fig. 90) to trace the signal path. To check the wiring, refer to the SUBGROUP MODULATOR wiring diagram (fig. 272).

*a. Test Setup, Direct Path.*

(1) Connect the OUTPUT jacks of the signal generator to the DIRECT PATH IN-

PUT EQUIP jacks of the SUBGROUP MODULATOR, and insert an open twin plug into the TRANSLATED PATH INPUT EQUIP jacks.

(2) Connect the OUTPUT EQUIP jacks of the SUBGROUP MODULATOR to the TERMINATING jacks of the LEVEL METER on the TRANSMITTER METER PANEL.

*b. Localization Tests, Direct Path.*

(1) Adjust the output level of the signal generator to 0 dbm and its frequency to 2,000 cps.

(2) The LEVEL METER should read −30 dbm ±2 db. If the reading differs widely from this value, proceed with the measurements listed in the following chart.

| Test No. | Electronic Multimeter ME-6A/U probe connections | Normal reading (volt ac) | Corrective measures |
|---|---|---|---|
| 1 | Terminal board TB10 of output coupler Z3, terminals 1 and 2 (ground). | 0. 78 | Check wiring between jacks J7 through J10 and terminals 1 and 2 of terminal board TB10. |
| 2 | Terminal board TB10 of output coupler Z3, terminals 5 and 6. | . 025 | Check wiring between terminals 5 and 6 of terminal board TB10 and jacks J17 and J18. Check output coupler Z3 (par. 275). |

*c. Test Setup, Translated Path.*

(1) Connect the OUTPUT jacks of the signal generator to the TRANSLATED PATH INPUT EQUIP jacks of the SUBGROUP MODULATOR and insert an open twin plug into the DIRECT PATH INPUT EQUIP jacks.

(2) Connect the OUTPUT EQUIP jacks of the SUBGROUP MODULATOR to the TERMINATING jacks of the LEVEL METER on the TRANSMITTER METER PANEL.

*d. Localization Tests, Translated Path.*

(1) Adjust the output level of the signal generator to 0 dbm and the frequency to 2,000 cps.

(2) The LEVEL METER should read −30 dbm +2 db. If the reading differs widely from this value, proceed with the measurement listed in the following chart.

| Test No. | Electronic Multimeter ME-6A/U probe connections | Normal reading (volt ac) | Corrective measures |
|---|---|---|---|
| 1 | Terminal board TB7 of converter Z2, terminals 1 and 2 (ground). | 0. 78 | Check wiring between jacks J13 through J16 and terminals 1 & 2 of terminal board TB7. |
| 2 | Terminal board TB7 of converter Z2, terminals 3 and 4 (ground). | 1. 6 | Perform isolation tests on converter (par. 270). |
| 3 | Mod filter 1 (FL1), terminals 1 and 2 (ground). | 1. 28 | Check wiring between terminals 3 and 4 of terminal board TB7 and terminals 3 and 4 of filter FL1. Check mod filter 1 (par. 274). |
| 4 | Terminal board TB3 of modulator Z1, terminals 3 and 4 (ground). | . 64 | Check wiring between terminals 1 and 2 of filter FL1 and terminals 1 and 2 of terminal board TB3. Check modulator Z1 (par. 271). |
| 5 | Terminal board TB3 of modulator Z1, terminals 5 and 6 (ground). | 7. 2 | Check wiring between terminals 1 and 2 of terminal board TB5 and terminals 5 and 6 of terminal board TB3. Check carrier supply Y1 (par. 272). |
| 6 | Mod filter 2 (FL2), terminals 1 and 2 (ground). | . 128 | Check wiring between terminals 3 and 4 of terminal board TB3 and terminals 3 and 4 of mod filter FL2. |
| 7 | Terminal board TB10 of output coupler Z3, terminals 5 and 6. | . 037 | Check wiring between terminals 1 and 2 of filter FL1 and terminals 3 and 4 of output coupler Z3. Check output coupler Z3 (par. 275 *a*(2)). |

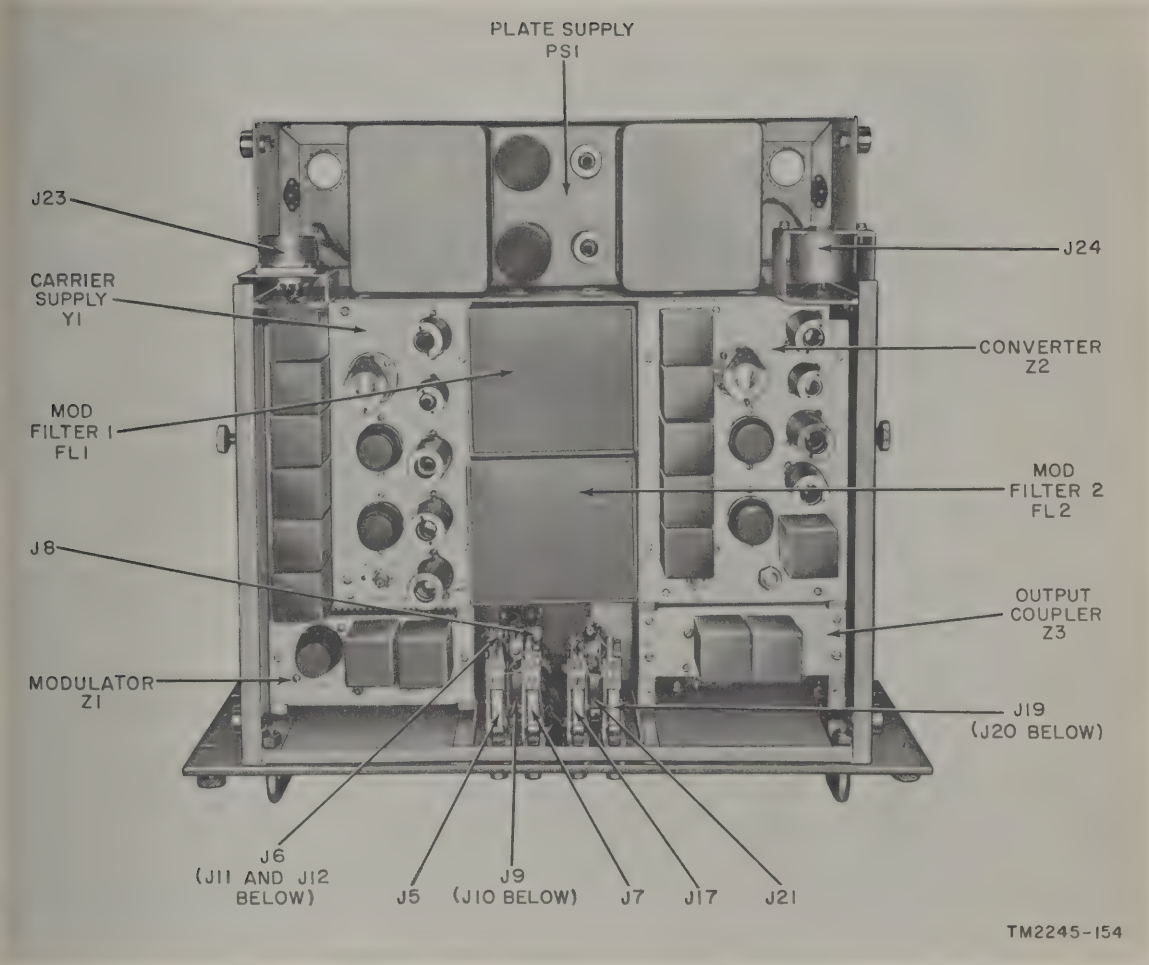



*Figure 181. SUBGROUP MODULATOR, top view.*

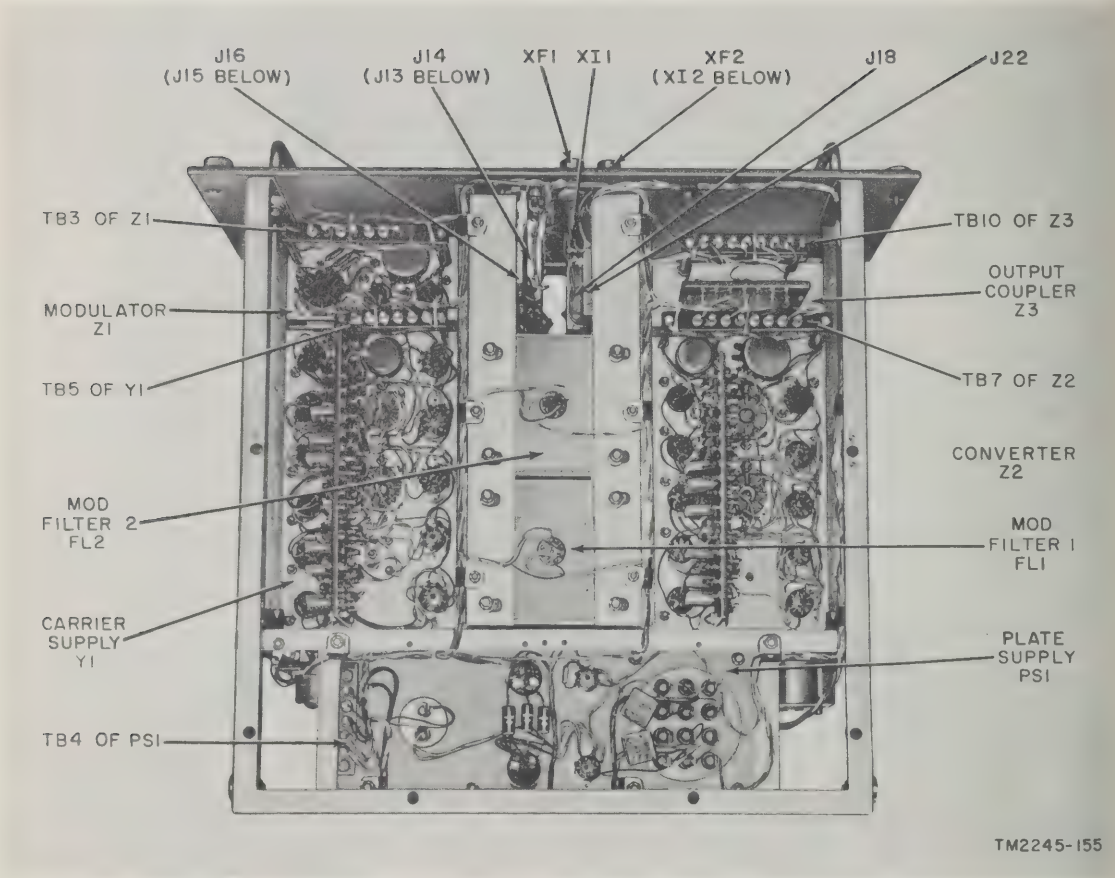



*Figure 182. SUBGROUP MODULATOR, bottom view.*

## 270. Trouble Isolation, SUBGROUP MODULATOR, Converter Z2

(figs. 183–185)

The general procedure to be followed in isolating trouble is discussed in paragraph 239*d*.

*a. Test Setup.* The test setup for isolating trouble in converter Z2 is the same as that used for localizing trouble in the translated path of the SUBGROUP MODULATOR (par. 269*c*). Usually the trouble isolation tests are made immediately following the localization tests, with the test relay left intact.

*b. Isolation Tests.* To isolate trouble in the converter, make the measurements listed in the following chart. Refer to the schematic diagram of the converter (fig. 92) and to the wiring diagram (fig. 273).

| Test No. | Electronic Multimeter ME–6A/U probe connections | Normal reading (volts ac) | Corrective measures |
|---|---|---|---|
| 1 | Tube socket XV10, terminal 6 and ground | 13 ±2 | Check tube V10. Replace crystal Y2. Measure voltages and resistances at tube socket XV10 (par 275). Check capacitors C18 and C19. Perform resonance test (*c* below). |
| 2 | Transformer T12, terminals 1 and 4 | 2.5±0.16 | Check transformer T12 (par. 275). |
| 3 | Transformer T14: | | |
| | terminals 6 and 7 | 7.0 | Check tube V11. Replace varistor CR4. Measure voltages and resistances at tube socket XV11 (par. 275). Check circuit wiring between transformers T12 and T14. Check resistors R61 through R68. Check capacitors C21 and C22 and transformers T13 and T14 (par. 275*a*(1)). |
| | terminals 5 and ground | 30 | |
| | terminals 3 and ground | 30 | |
| 4 | Tube socket XV13: | | |
| | terminal 2 and ground | 16 | Check tube V12. Check resistors R71 through R73. Check wiring between tube socket XV12 and XV13. Make voltage and resistance measurements at tube socket XV12 (par. 275). |
| | terminal 7 and ground | 16 | |
| 5 | Transformer T15, terminals 4 and 6 | 7.2 | Check tube V13. Check adjustment of resistor R77. Check transformer T15 (par. 275*a*(1)). Check resistors R74 through R82 and varistor CR5. Check capacitor C24. Make voltage and resistance measurements at tube socket XV13 (par. 275). Check transformers T16 and T17 (par. 275). |

*c. Resonance Test, Converter Z2.* If a normal voltage is not obtained in test No. 1 (*b* above), the oscillator stage of the converter Z2 is not oscillating properly. If the indicated corrective measures are not effective, check the oscillator with a resistor substituted for crystal Y1 by making the test given in (1) through (5) below.

(1) Remove crystal Y2 and connect a 100,000-ohm, ½-watt resistor between the terminals of the crystal socket XY2.

(2) Connect Electronic Multimeter ME–6A/U between terminal 6 of tube socket XV10 and ground to measure the oscil lator output. Normal reading is 13 volts ac ±2 volts.

(3) Connect Frequency Meter FR–67/U or Frequency Counter AN/USM–26 between terminal 8 of tube socket XV10 and ground to measure the oscillator frequency. Normal reading is 19 kc ± 2 kc.

(4) If the voltage and frequency indicated in (2) and (3) above are not normal, check capacitor C20 and transformer T12 (par. 275*a*(1)).

(5) Remove the 100,000-ohm resistor and restore crystal Y2 to its socket. Normal reading of the frequency meter is 19,380 cps ±3 cps.

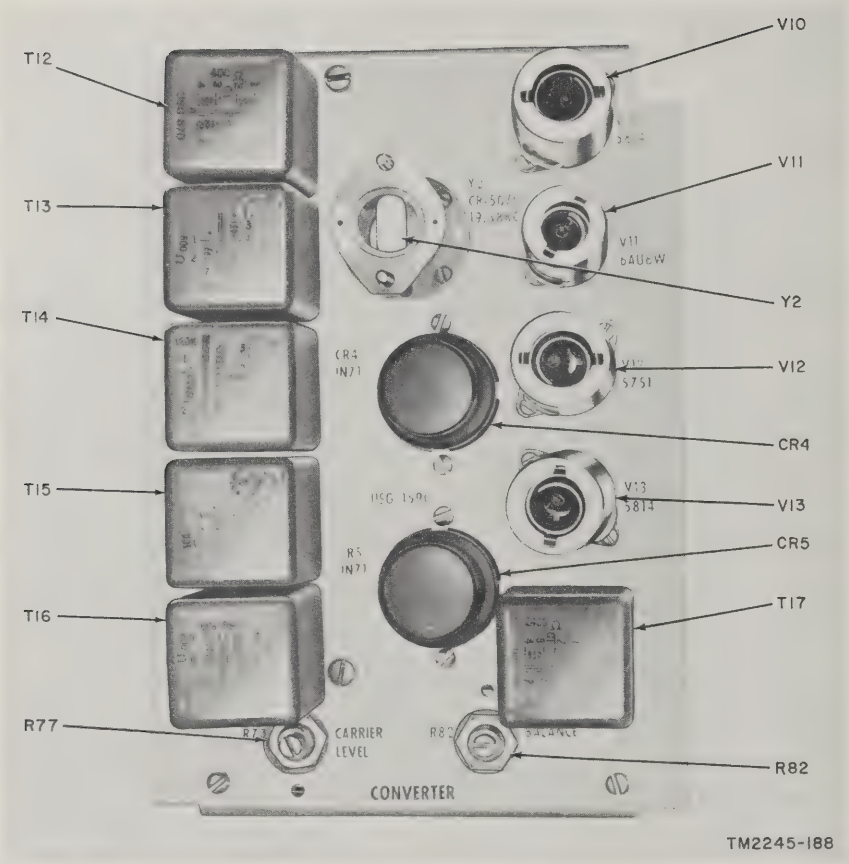



*Figure 183. Converter, top view.*

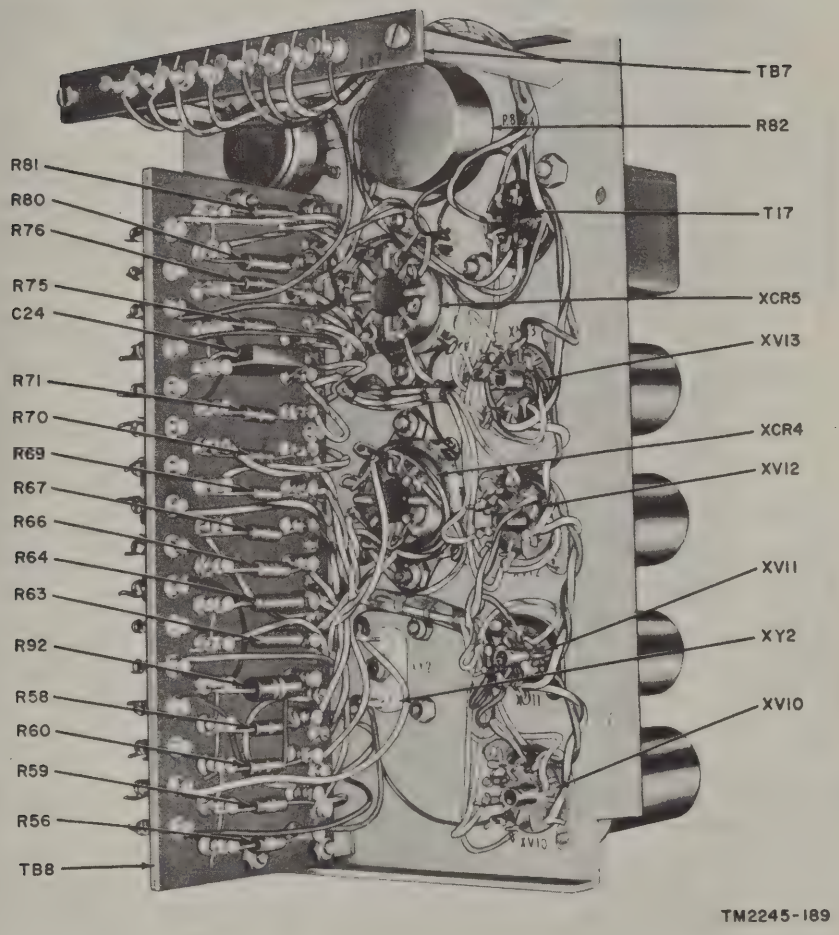



*Figure 184. Converter, bottom view from right side.*

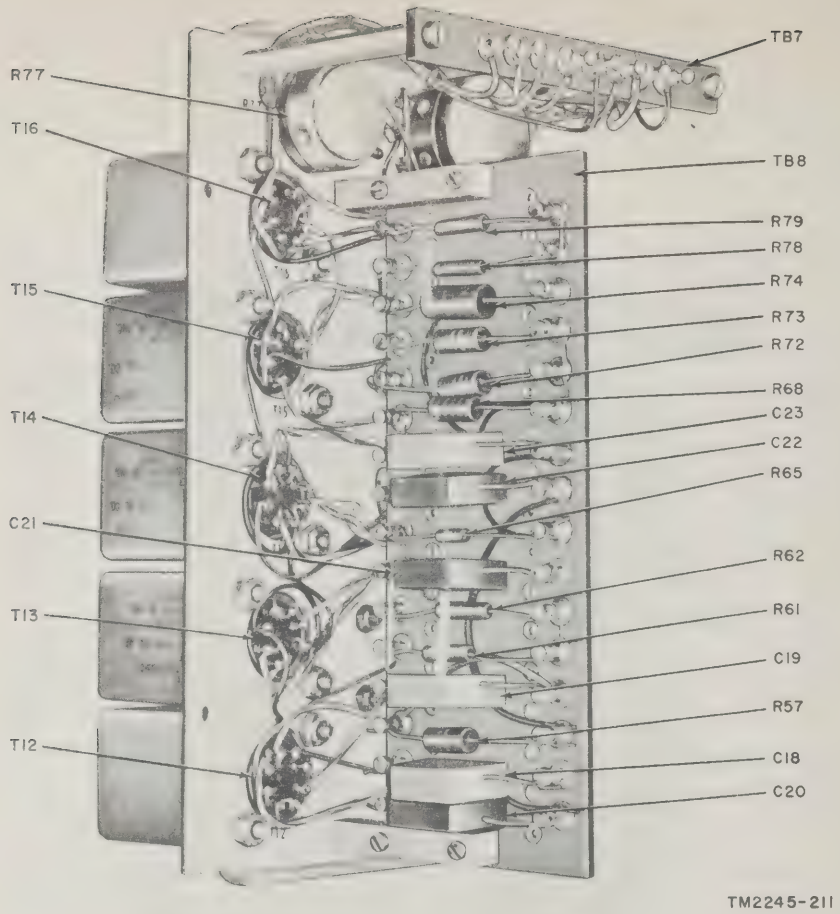



*Figure 185. Converter, bottom view from left side.*

## 271. Trouble Isolation, SUBGROUP MODULATOR, Modulator Z1

The general procedure to be followed in isolating trouble is discussed in paragraph 239*d*. To isolate trouble in modulator Z1, make the tests listed in *a* through *c* below. A special test setup is not required. Refer to the schematic diagram of the modulator (fig. 100) and to the wiring diagram (fig. 274).

*a*. Connect the ground of Electronic Multimeter ME–6A/U to terminal 2 of transformer T4 and the other probe to terminal 2 of transformer T5, then read the voltage. Repeat the measurement between terminal 3 of transformer T4 and terminal 3 of transformer T5. If a normal reading of 7 volts ac is not obtained in both measurements, check the wiring from terminals 5 and 6 of terminal board TB3 to variable resistor R17 and transformer T5. Check variable resistor R17.

*b*. Measure the resistance of resistors R18, R19, R20, and R21. All four resistances should be 388 to 396 ohms.

*c*. Check all of the circuit wiring from terminals 1 and 2 to terminals 3 and 4 of terminal board TB3. Check transformers T4 and T5 (par. 275*a*(4)).

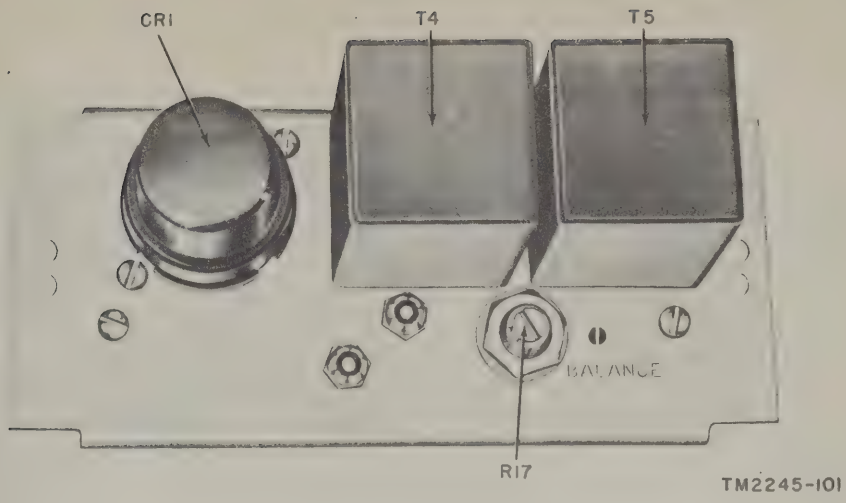



*Figure 186. Modulator, top view.*

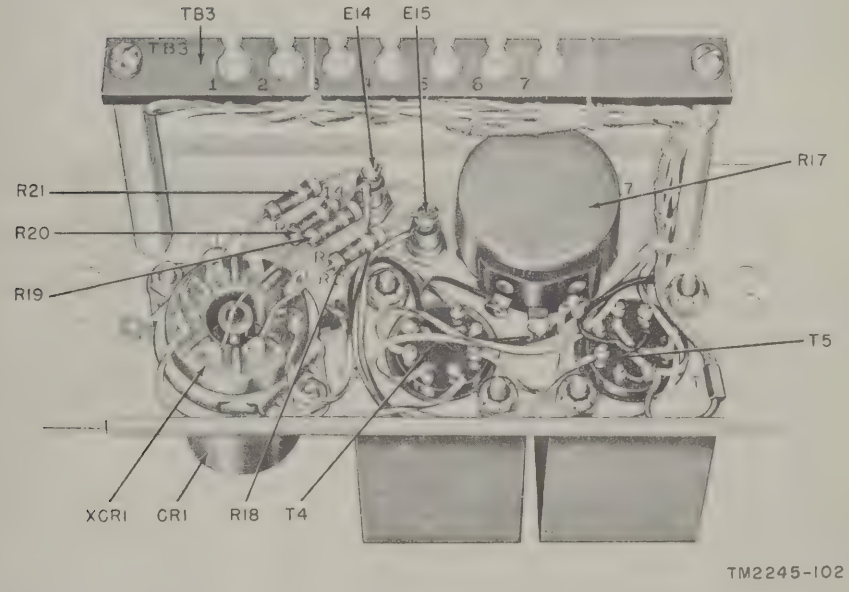



*Figure 187. Modulator, bottom view.*

## 272. Trouble Isolation, SUBGROUP MODULATOR, Carrier Supply Y1

(figs. 188–190)

The general procedure to be followed in isolating trouble is discussed in paragraph 239*d*. To isolate trouble in carrier supply Y1, make the tests listed in *a* and *b* below. A special test setup is not required. Refer to the schematic diagram (fig. 96) of the carrier supply and to the wiring diagram (fig. 275).

*a. Isolation Tests, Carrier Supply Y1.*

| Test No. | Electronic Multimeter ME-6A/U probe connections | Normal reading (volts ac) | Corrective measures |
|---|---|---|---|
| 1 | Tube socket XV5, terminal 6 and ground | 13 ±2 | Check tube V5. Replace crystal Y1. Measure voltages and resistances at tube socket XV5 (par. 275). Check capacitors C9 and C10. Perform resonance test (*b* below). |
| 2 | Transformer T6, terminals 1 and 4 | 2.5±0.16 | Check transformer T6 (par. 275). |
| 3 | Transformer T8, terminals 3 and 4, terminals 5 and 6. | 4.3 | Check tube V6. Replace varistor CR2. Measure voltages and resistances at tube socket XV6 (par. 275). Check circuit wiring between transformers T6 and T8. Check resistors R31 through R34 and R41. Check capacitor C12 and transformers T7 and T8 (par. 275*a*(3)). |
| 4 | Transformer T9, terminals 1 and 2 | 5.7 | Replace varistor CR3. Check circuit wiring between transformers T8 and T9. Check resistors R35 through R38 and R42. |
| 5 | Tube socket XV7, terminal 2 and ground, terminal 7 and ground. | 2.7 | Check circuit wiring between transformer T9 and tube socket XV7. Check transformer T9 (par. 275*a*(3)). |
| 6 | Tube socket XV8, terminal 2 and ground, terminal 7 and ground. | 17 | Check tube V7. Measure voltages and resistances at tube socket XV8 (par. 275). Check circuit wiring between tube sockets XV7 and XV8. Check resistors R45 and R46, capacitors C15. Check transformer T10 (par. 275*a*(3)). |
| 7 | Tube socket XV9, terminal 2 and ground, terminal 7 and ground. | 37 | Check tube V8. Measure voltages and resistances at tube socket XV8 (par. 275). Check circuit wiring between tube sockets XV8 and XV9. |
| 8 | Terminal board TB5, terminals 1 and 2 (ground). | 7.2 | Readjust GAIN control (variable resistor R53). Check tube V9. Measure voltages and resistances at tube socket XV9 (par. 275). Check circuit wiring between tube socket XV9 and terminal board TB5. Check resistors R51 through R53 and capacitor C16. Check transformer T11 (par. 275*a*(3)). |

*b. Resonance Test, Carrier Supply Y1.* If a normal voltage reading is not obtained in test No. 1 (*a* above), the oscillator stage of the carrier supply is not oscillating properly. If the indicated corrective measures are not effective, check the oscillator with a resistor substituted for the crystal by making the test described in (1) through (5) below.

(1) Remove crystal Y1 and connect a 100,000-ohm ½-watt resistor between the terminals of crystal socket XY1.

(2) Connect Electronic Multimeter ME-6A/U between terminal 6 of tube socket XV5 and ground to measure the oscillator output. Normal reading is 13 volts±2 volts.

(3) Connect Frequency Meter FR-67/U or Frequency Counter AN/USM-26 between terminal 8 of tube socket XV5 and ground to measure the oscillator frequency. Normal reading is 25 kc±2 kc.

(4) If the voltage and frequency ((2) and (3) above) are not normal, check capacitor C11 and transformer T6 (par. 275*a* (3)).

(5) Remove the 100,000-ohm resistor and restore crystal Y1 to its socket. Normal reading of the frequency meter is 25,160 cps±3 cps.

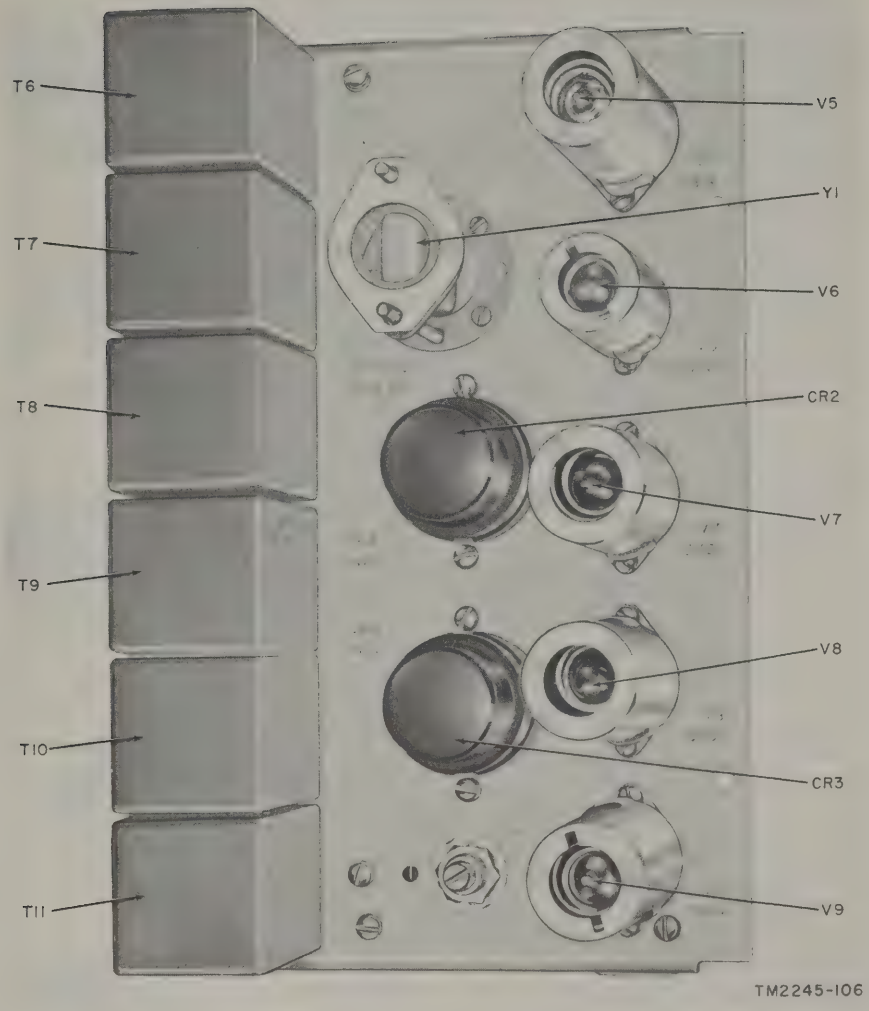



*Figure 188. Carrier supply, top view.*

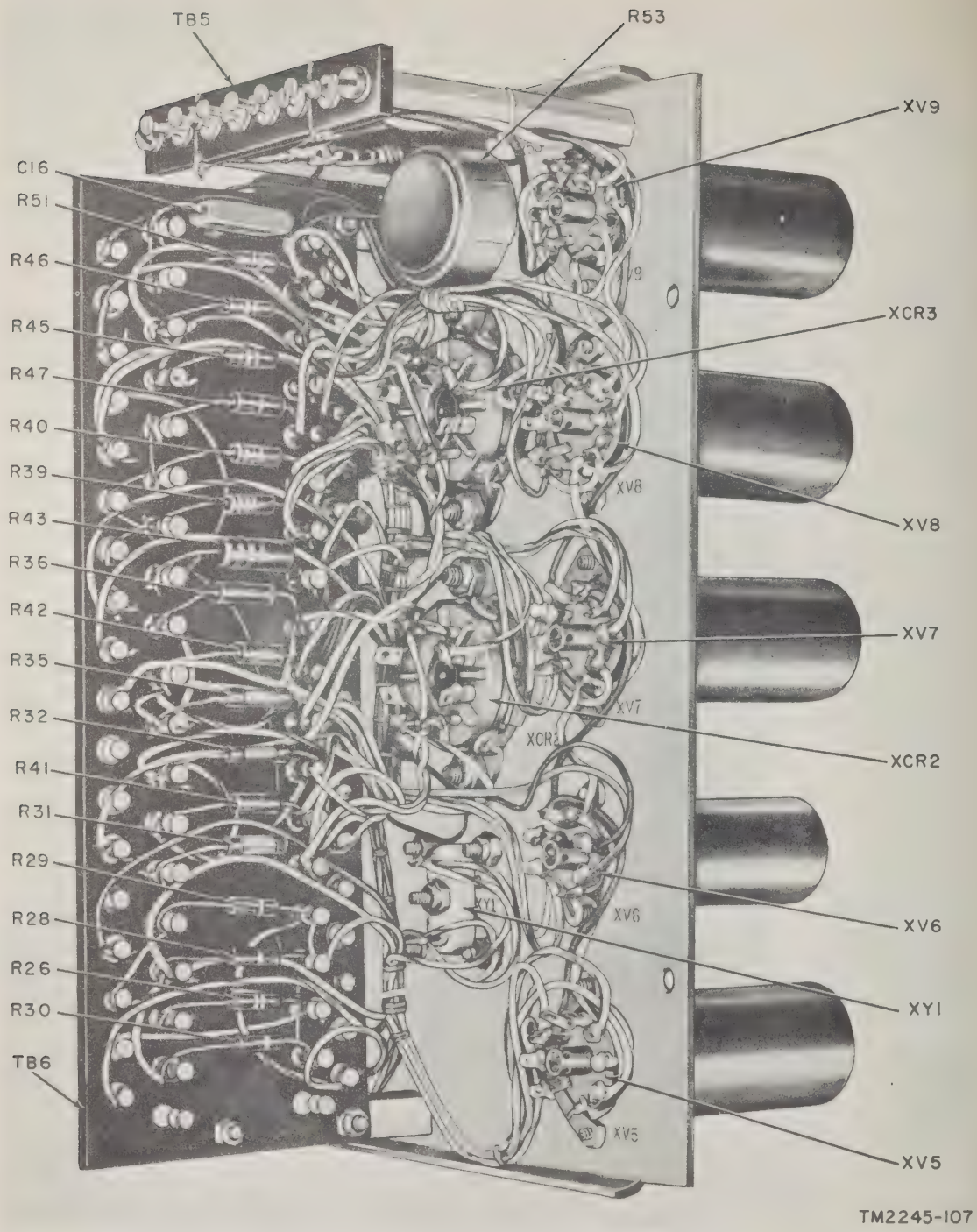



*Figure 189. Carrier supply, bottom view from right side.*

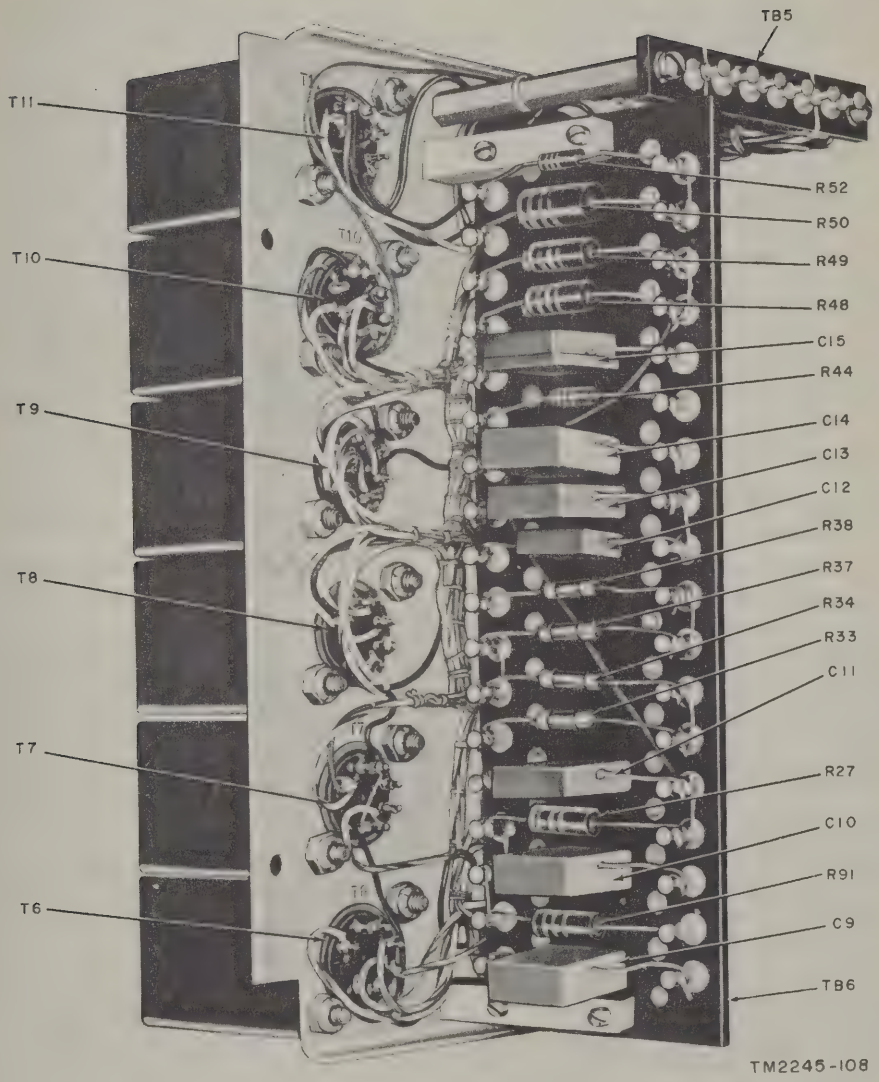



*Figure 190. Carrier supply, bottom view from left side.*

## 273. Trouble Isolation, SUBGROUP MODULATOR, Plate Supply PS1

(figs. 191 and 192)

The general procedure to be followed in isolating trouble is discussed in paragraph 239*d*. To isolate trouble in plate supply PS1, make the following tests. A special test setup is not required. Refer to the schematic diagram (fig. 102) of the plate supply and to the wiring diagram (fig. 276).

| Test No. | Multimeter TS–352/U probe connections | Normal reading (volts) | Corrective measures |
|---|---|---|---|
| 1 | Transformer T3, terminals 1 and 3, terminals 2 and 4. | 115 ac | Check ac power source. Check power circuit continuity. |
| 2 | Tube socket XV3, terminal 6 and ground | 250 ac | Check transformer T3 (par. 275*a*(5)) and wiring. Check capacitor C30. |
| 3 | Tube socket XV4, terminal 6 and ground | 250 ac | Check transformer T3 (par. 275*a*(5)) and wiring. Check capacitor C31. |
| 4 | Inductor L1, terminal 2 and ground | 210 dc | Check tubes V3 and V4. Measure voltages and resistances at tube sockets XV3 and XV4 (par. 275). |
| 5 | Terminal board TB4, terminal 1 and ground. | 200 dc | Check wiring between inductor L1 and terminal board TB4. Check inductor L1, capacitors C7 and C8, resistors R22, R23, and R24. |
| 6 | Terminal board TB4, terminal 3 and ground, terminal 5 and ground. | 3.15 ac | Check wiring between terminal board TB4 and transformer T3. Check transformer T3 (par. 275*a*(5)). |

## 274. Filter Tests, SUBGROUP MODULATOR

(figs. 180 and 193)

Mod filter 1 and mod filter 2 of the SUBGROUP MODULATOR are nonrepairable sealed units that must be replaced if found to be defective. These filters are tested by measuring the transmission characteristics of each filter at specified frequencies with the filter removed from the SUBGROUP MODULATOR circuit. Measure also the resistance between the filter terminals (par. 275).

*a. Test Equipment Required.* The test equipment required for filter testing consists of Signal Generator SG–15/PCM, Frequency Meter FR–67/U or Frequency Counter AN/USM–26, and Electronic Multimeter ME–6A/U. The signal generator provides the input signal for the filter under test, and the frequency meter provides accurate measurements of the test frequency. The electronic multimeter measures the input and output voltages.

*b. Connections.* The connections for testing mod filter 1 are shown in figure 193 and for mod filter 2 in figure 180. Perform the following tests:

(1) When testing mod filter 1, connect one output terminal of the signal generator to terminal 1 through a 10,000-ohm, ½-watt resistor. When testing mod filter 2, connect one output terminal of the signal generator to terminal 1 through a 600-ohm resistor.

(2) Connect the second output terminal of the signal generator to terminal 2 of the filter under test.

(3) Connect terminal 2 of the filter to ground.

(4) Connect the input leads of the frequency meter to the output terminals of the signal generator.

(5) Connect a 10,000-ohm, ½-watt resistor between terminals 3 and 4 of the filter.

*c. Measurements.* Use the procedure given in (1) through (6) below to make the test measurements on mod filters 1 and 2.

(1) Connect the electronic multimeter to the output terminals of the signal generator.

(2) Adjust the output frequency of the signal generator to the frequency specified for test No. 1 in *d* or *e* below. For accurate frequency adjustment, use the frequency meter rather than the reading of the frequency selection dial on the signal generator.

(3) Adjust the signal generator output voltage to voltage E1 specified in *d* or *e* below.

(4) Disconnect the multimeter from the signal generator and connect it between the output terminals of the filter.

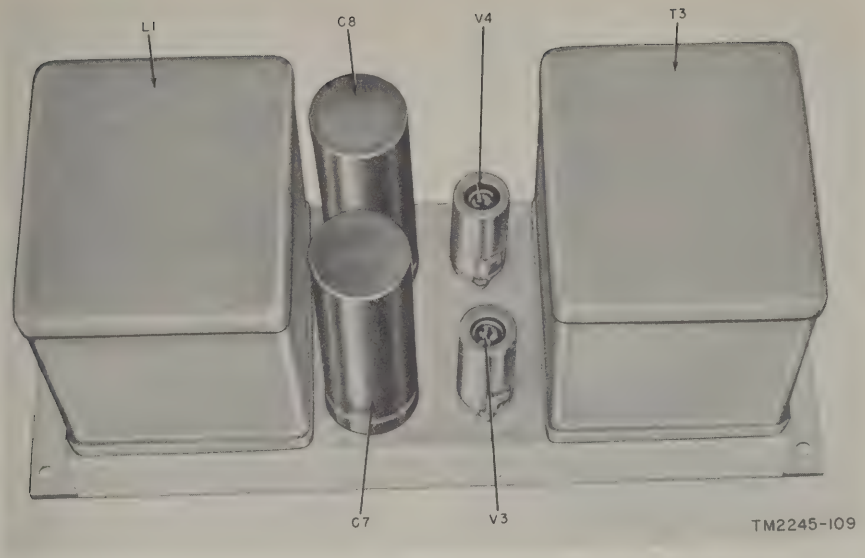



*Figure 191. Plate supply, top view.*

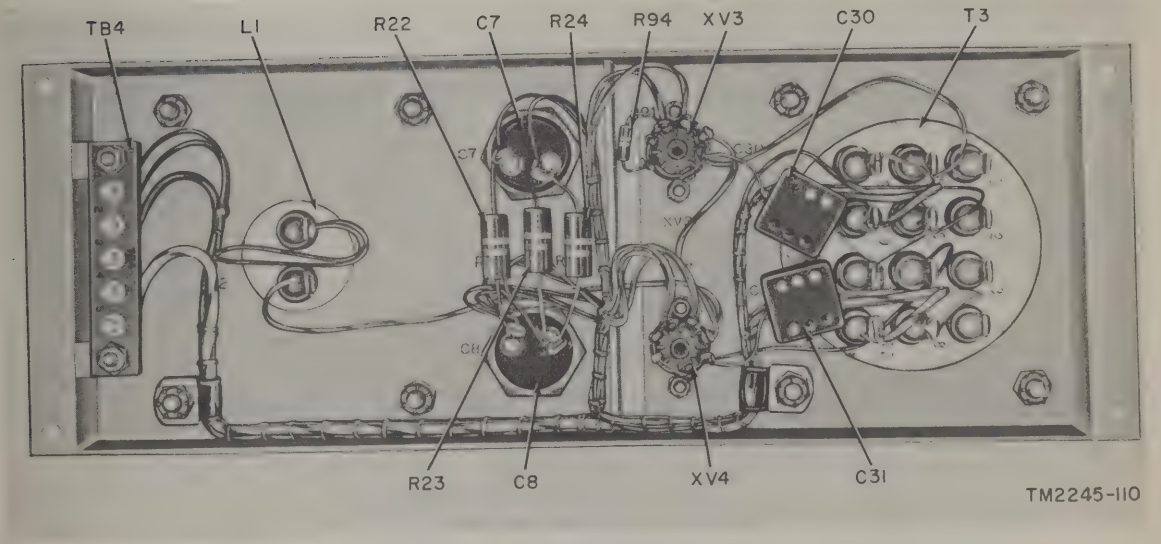
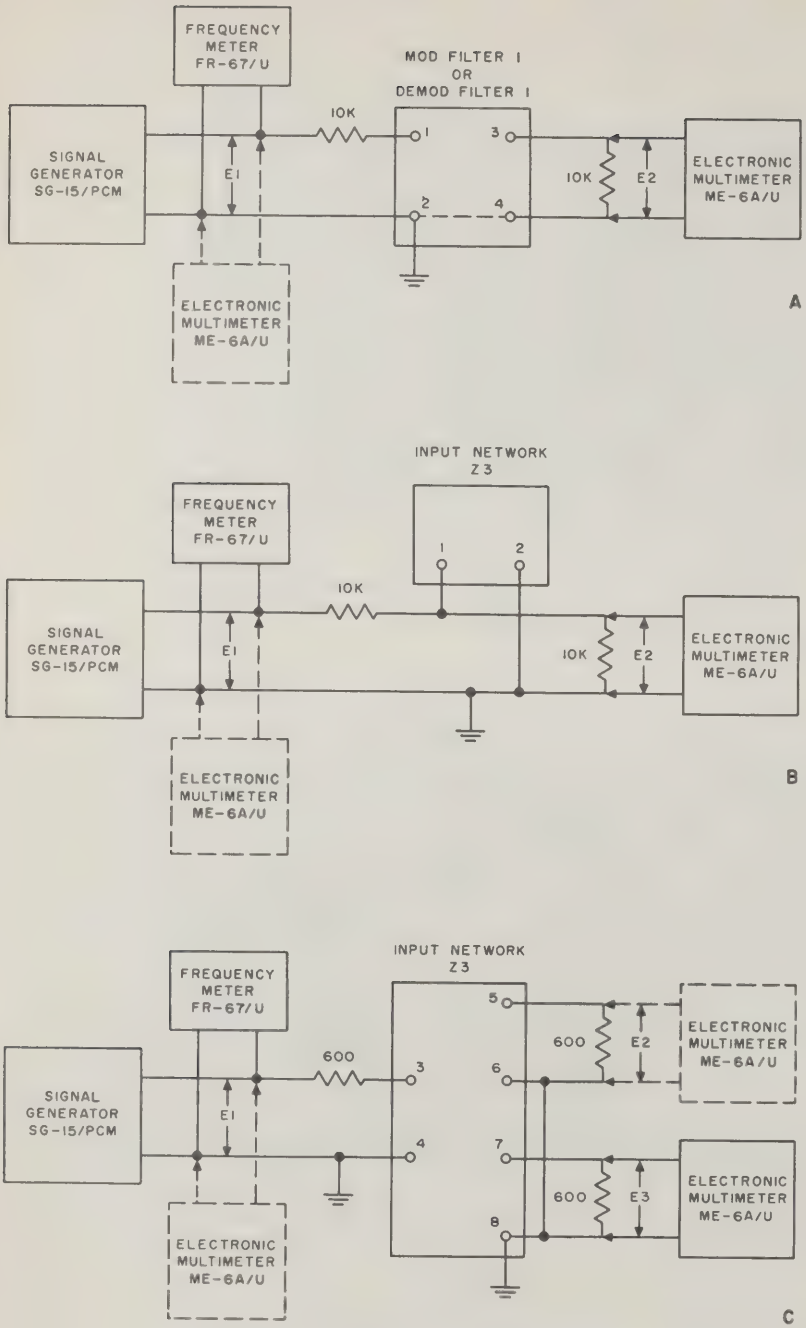



*Figure 192. Plate supply, bottom view.*




NOTES:

1. RESISTORS ARE IN OHMS.
2. ONLY ONE ELECTRONIC MULTIMETER ME-6A/U IS REQUIRED FOR THESE TEST ARRANGEMENTS.

TM2245-358

*Figure 193. Mod filter 1 and demod filter 1, test arrangement.*

(5) Measure the filter output voltage (voltage E2 in *d* and *e* below).

(6) Repeat the procedure given in (1) through (5) above for each frequency listed in the table of *d* and *e* below.

*d. Normal Readings, Mod Filter 1.* Mod filter 1 is acceptable for use if voltage readings E2 in tests No. 1 through 8 in the following chart fall within the limits listed.

| Test No. | Frequency (cps) | E1 (volts) | E2 (volts) |
|---|---|---|---|
| 1 | 3,000 through 4,000 | 7. 75 | 0. 009 max |
| 2 | 5,700 | 7. 75 | . 029 max |
| 3 | 6,000 | 7. 75 | . 065 max |
| 4 | 6,400 | 7. 75 | 2. 31 min |
| 5 | 6,600 through 8,000 | 7. 75 | 2. 91 min |
| 6 | 8,600 | 7. 75 | 2. 31 min |
| 7 | 10,000 | 7. 75 | . 092 max |
| 8 | 11,000 through 15,000 | 7. 75 | . 009 max |

*e. Normal Readings, Mod Filter 2.* Mod filter 2 is acceptable for use if voltage readings E2 in tests No. 1 through 6 in the following chart fall within the limits listed.

| Test No. | Frequency (cps) | E1 (volts) | E2 (volts) |
|---|---|---|---|
| 1 | 200 | 1. 5 | 2. 12 min |
| 2 | 300 through 1,300 | 1. 5 | 2. 38 min |
| 3 | 1,700 | 1. 5 | 2. 12 min |
| 4 | 2,800 ±50 | 1. 5 | . 013 max |
| 5 | 4,400 | 1. 5 | . 019 max |
| 6 | 5,500 through 10,500 | 1. 5 | . 013 max |

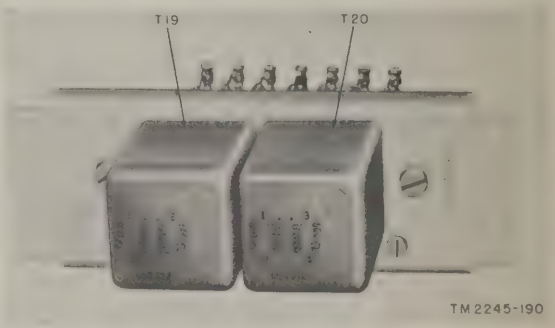



*Figure 194. Output coupler, top view.*

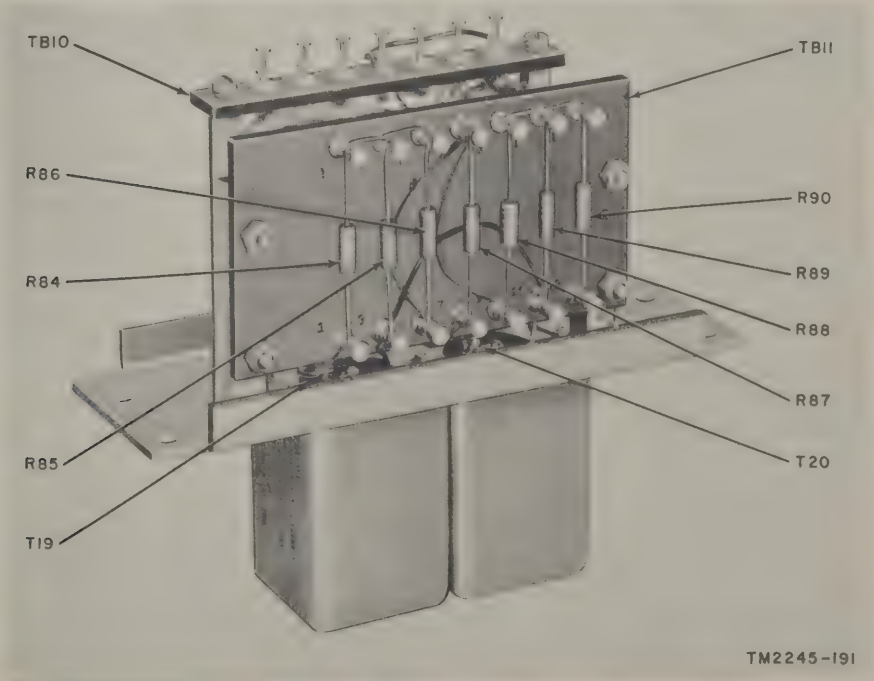



*Figure 195. Output coupler, bottom view.*

## 275. Additional Troubleshooting Information, SUBGROUP MODULATOR

*a. Typical Resistance Readings.* Measure the resistances of transformers and filters with all connections removed from the terminals. Measure the resistance at the terminals of tube sockets with the connections intact and all conditions normal except that the power is disconnected from the component. Typical resistance measurements of the SUBGROUP MODULATOR subassemblies are given in (1) through (5) below.

(1) *Converter Z2.*

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Tube sockets: | | | |
| XV10 | 1 | Ground | 22, 000 |
| | 2 | Ground | 220, 000 |
| | 3 | Ground | 2, 200 |
| | 7 | Ground | 22, 000 |
| | 8 | Ground | 1, 500 |
| XV11 | 1 | Ground | 78 |
| | 2, 7 | Ground | 470 |
| | 5 | 6 | 33, 000 |
| XV12 | 2, 7 | Ground | 56, 000 |
| | 3, 8 | Ground | 1, 000 |
| XV13 | 1 | 6 | 47 |
| | 3, 8 | Ground | 5, 100 |
| Transformers: | | | |
| T12 | 1 | 2 | 1. 7 |
| | 3 | 4 | 1. 7 |
| | 5 | 7 | 12 |
| T13 | 1 | 2 | 5. 4 |
| | 3 | 4 | 34 |
| | 5 | 6 | 34 |
| T14 | 1 | 2 | 70 |
| | 3 | 4 | 49 |
| | 6 | 7 | 6. 9 |
| T15 | 1 | 2 | 21 |
| | 2 | 3 | 21 |
| | 4 | 6 | 10 |
| T16 | 1 | 2 | 55 |
| | 3 | 4 | 55 |
| | 5 | 6 | 48 |
| T17 | 1 | 2 | 56 |
| | 3 | 4 | 56 |
| | 5 | 6 | 200 |

(2) *Output coupler Z3.*

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Transformers: | | | |
| T19, T20 | 1 | 2 | 25 |
| | 3 | 4 | 35 |
| Mod filter 1: | | | |
| (FL1) | 1 | 3 | Infinite |
| | 2 | 4 | 0 |
| | 1 | 2 | Infinite |
| | 3 | 4 | Infinite |
| Mod filter 2: | | | |
| (FL2) | 1 | 3 | Infinite |
| | 2 | 4 | Infinite |
| | 1 | 2 | 4. 5 |
| | 3 | 4 | 261 |

(3) *Carrier supply Y1.*

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Tube sockets: | | | |
| XV5 | 1 | Ground | 22, 000 |
| | 2 | Ground | 220, 000 |
| | 3 | Ground | 2, 200 |
| | 7 | Ground | 22, 000 |
| | 8 | Ground | 1, 500 |
| XV6 | 1 | Ground | 78 |
| | 2, 7 | Ground | 470 |
| | 5 | 6 | 33, 300 |
| XV7 | 1 | 6 | 18. 6 |
| | 2 | Ground | 9. 5 |
| | 3, 8 | Ground | 330 |
| | 7 | Ground | 9. 5 |
| XV8 | 2 | Ground | 56, 000 |
| | 3, 8 | Ground | 1, 000 |
| | 7 | Ground | 56, 000 |
| XV9 | 1 | 6 | 47 |
| | 3, 8 | Ground | 5, 100 |
| Transformers: | | | |
| T6 | 1 | 4 | 1. 7 |
| | 5 | 7 | 12 |
| T7 | 1 | 2 | 5. 4 |
| | 3 | 6 | 78 |
| T8 | 1 | 2 | 166 |
| | 3 | 4 | 15 |
| | 5 | 6 | 15 |
| T9 | 1 | 2 | 9. 3 |
| | 3 | 5 | 19 |
| | 6 | 8 | 157 |
| T10 | 1 | 2 | 2. 4 |
| | 3 | 4 | 2. 4 |
| | 5 | 6 | 9. 3 |
| | 7 | 8 | 9. 3 |
| T11 | 1 | 3 | 47 |
| | 4 | 6 | 10 |

(4) *Modulator Z1.*

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Transformers: | | | |
| T4, T5 | 1 | 2 | 28 |
| | 3 | 4 | 28 |
| | 5 | 6 | 200 |

(5) *Plate supply PS1.*

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Transformer: | | | |
| T3 | 1 | 3 | 4.3 |
| | 2 | 4 | 5 |
| | 5 | 6 | 70 |
| | 6 | 7 | 67 |
| | 8 | 9 | .3 |
| | 10 | 12 | .2 |
| Inductor L1 | 1 | 2 | 92 |
| Tube sockets: | | | |
| XV3 | 6 | Ground | 70 |
| XV4 | 6 | Ground | 67 |

*b. Typical Voltage Readings.* Measure voltages with the component connected to its regular power supply with tubes in place and all conditions normal. Typical voltage readings for subassemblies of the SUBGROUP MODULATOR are given in (1) through (3) below.

(1) *Converter Z2.*

| Item | Measure from terminal | Measure to terminal | Voltage (volts) |
|---|---|---|---|
| Tube sockets: | | | |
| XV10 | 1 | Ground | +28 dc |
| | 3 | Ground | +1.2 dc |
| | 4, 5 | 9 | 6.3 ac |
| | 6 | Ground | +200 dc |
| | 8 | Ground | +7.0 dc |
| XV11 | 3 | 4 | 6.3 ac |
| | 5 | Ground | +200 dc |
| | 6 | Ground | +150 dc |
| | 7 | Ground | +2.5 dc |
| XV12 | 1, 6 | Ground | +30 dc |
| | 3, 8 | Ground | +1.0 dc |
| | 4, 5 | 9 | 6.3 ac |
| XV13 | 1, 6 | Ground | +200 dc |
| | 2, 7 | Ground | +30 dc |
| | 3, 8 | Ground | +70 dc |
| | 4, 5 | 9 | 6.3 ac |

(2) *Carrier supply Y1.*

| Item | Measure from terminal | Measure to terminal | Voltage (volts) |
|---|---|---|---|
| Tube sockets: | | | |
| XV5 | 1 | Ground | +27 dc |
| | 3 | Ground | +1.25 dc |
| | 4, 5 | 9 | 6.3 ac |
| | 6 | Ground | +200 dc |
| | 8 | Ground | +8 dc |
| XV6 | 3 | 4 | 6.3 ac |
| | 5 | Ground | +200 dc |
| | 6 | Ground | +145 dc |
| | 2, 7 | Ground | +2.5 dc |
| XV7 | 1 | Ground | +200 dc |
| | 3, 8 | Ground | +1.6 dc |
| | 4, 5 | 9 | 6.3 ac |
| | 6 | Ground | +200 dc |
| XV8 | 1 | Ground | +33 dc |
| | 3, 8 | Ground | +.8 dc |
| | 4, 5 | 9 | 6.3 ac |
| | 6 | Ground | +33 dc |
| XV9 | 1 | Ground | +200 dc |
| | 2 | Ground | +33 dc |
| | 3, 8 | Ground | +75 dc |
| | 4, 5 | 9 | 6.3 ac |
| | 6 | Ground | +200 dc |
| | 7 | Ground | +33 dc |

(3) *Plate supply PS1.*

| Item | Measure from terminal | Measure to terminal | Voltage (volts) |
|---|---|---|---|
| Transformer | 1 | 3 | 115 ac |
| T3 | 2 | 4 | 115 ac |
| | 10 | 12 | 6.3 ac |
| Tube socket: | | | |
| XV3 | 6 | Ground | 250 ac |
| | 3 | 4 | 6.3 ac |
| | 1, 2, 5, 7 | Ground | +210 dc |
| Tube socket: | | | |
| XV4 | 6 | Ground | 250 ac |
| | 3 | 4 | 6.3 ac |
| | 1, 2, 5, 7 | Ground | +210 dc |
| Inductor L1 | 1 | Ground | +200 dc |
| | 2 | Ground | +210 dc |

## 276. Operation Test, LEVEL CONTROL & PLATE SUPPLY

The general procedure to be followed in making an operational test is described in paragraph 239*b*. To determine whether or not the LEVEL CONTROL & PLATE SUPPLY is functioning properly, it is necessary to check the functioning of the A and B amplifiers and the A and B plate supplies. Before starting the test, record the normal setting of the LEVEL ADJUST control. Restore it to this setting after the test is completed.

*a. Test Setup.* The LEVEL CONTROL & PLATE SUPPLY remains in place as installed and connected to its normal power supply. Connect Signal Generator SG–15/PCM and the LEVEL METER on the TRANSMITTER METER PANEL as follows:

(1) Connect the OUTPUT jacks of the signal generator to the INPUT EQUIP jacks of the LEVEL CONTROL & PLATE SUPPLY.

(2) Connect the TERMINATING jacks of LEVEL METER to the OUTPUT EQUIP jacks of the LEVEL CONTROL & PLATE SUPPLY. Set the ATTENUATOR control of the LEVEL METER to +10.

*b. Amplifier Test.* Perform the steps outlined in (1) through (10) below to check the performance of AMPLIFIER A and AMPLIFIER B both as the amplifier in use and as the spare amplifier.

(1) Set the AMPLIFIER IN USE switch of the LEVEL CONTROL & PLATE SUPPLY to the A position. Set the CHANNELS 1–8 and AMPLIFIER A switch to the A position and the CHANNEL 9–16 and AMPLIFIER B switch to the B position. Set the LEVEL ADJUST control to 20.

(2) Adjust the output level of the signal generator to −10 dbm and its frequency to 400 cps. The LEVEL METER should read +10 dbm ± 1 db.

(3) Change the AMPLIFIER IN USE switch to the B position. The LEVEL METER should read +10 dbm ± 1 db.

(4) Change the CHANNELS 1–8 AND AMPL A switch to the B position and the CHANNELS 9–16 AND AMPL B switch to the A position. THE LEVEL METER should read +10 dbm ± 1 db.

(5) Change the frequency of the signal generator to 3,000 cps with the output level at −10 dbm. The LEVEL METER should read +10 dbm ± 1db.

(6) Change the AMPLIFIER IN USE switch to the A position. The reading on the LEVEL METER should remain at +10 dbm ± 1 db.

(7) Disconnect the signal generator from the INPUT EQUIP jacks and connect it to the SPARE AMPL INPUT jacks. Disconnect the LEVEL METER from the OUTPUT EQUIP jacks and connect it to the SPARE AMPL OUTPUT jacks.

(8) Readjust the level of the signal generator to −40 dbm with the frequency remaining at 3,000 cps. The LEVEL METER should read +10 dbm ±1 db.

(9) Disconnect all plugs from the LEVEL CONTROL & PLATE SUPPLY and restore all controls to their normal positions (par. 83*h*(1)–(3)).

*c. Plate Supply Test.* Perform the steps described in (1) through (4) below to check the performance of the plate supplies and as a check on the wiring from the outputs of the plate supplies.

(1) Remove the +200 VDC fuse from TRANSMITTER CHANNELS 1 and 2. Check that the associated BLOWN FUSE INDICATOR glows. Connect the positive probe of Multimeter TS–352/U to the tip of the fuse holder and the negative probe to ground. The meter should read +200 volts ±5 volts.

(2) Momentarily change the CHANNELS 1–8 and AMPLIFIER A switch to the B position. Check that the BLOWN FUSE INDICATOR continues to glow and that the voltage is at least 190 volts. Disconnect the multimeter.

(3) Replace the fuse in TRANSMITTER CHANNELS 1 and 2 and remove the similar fuse from TRANSMITTER CHANNELS 9 and 10. Check that the BLOWN FUSE INDICATOR glows. Connect the multimeter as in (1) above. The meter should read +200 volts ±5 volts.

(4) Momentarily change the CHANNELS 9–16 and AMPLIFIER B switch to the A position. Check that the BLOWN FUSE INDICATOR continues to glow, and that the voltage reading is greater than +190 volts. Restore the switch to the B position, disconnect the multimeter, and replace the +200 VDC fuse in TRANSMITTER CHANNELS 9 and 10.

## 277. LEVEL CONTROL & PLATE SUPPLY, Troubleshooting Chart

The following chart is supplied as an aid in locating trouble in the LEVEL CONTROL & PLATE SUPPLY. This chart lists the symptoms which are observed when sectionalizing Telegraph Terminal AN/FGC–29 for trouble. The chart also lists the probable cause of a symptom and gives the localization and isolation procedures to be used to correct it. After the trouble has been localized to a subassembly or circuit in the LEVEL CONTROL & PLATE SUPPLY, trouble isolation tests, or voltage and resistance measurements should be sufficient to locate the trouble. The trouble isolation tests are given in paragraphs 279 and 280. The voltage and resistance measurements are given in tabular form in paragraph 281. If the trouble-shooting chart indicates the specific subassembly or circuit in which the trouble is likely to be found, trouble localization or isolation should begin with the test indicated by the paragraph reference in the *Correction* column. Otherwise the trouble localization procedures should begin with the first step given in paragraph 278.

| Symptom | Probable trouble | Correction |
|---|---|---|
| 1. No transmission through LEVEL CONTROL & PLATE SUPPLY with either AMPLIFIER A or AMPLIFIER B in use. | *a.* Failure of ac power supply. | *a.* Check ac power source. Check power cord and connectors. Check for presence of 230 v ac between terminals 1 and 4 on transformer T3 of both plate supply PS1 and PS2. Check fuses F3 through F6 and indicators I 3 through I 6. Check wiring between connector J17 and plate supply PS1 and PS2. |
| | *b.* Defective part or wiring in INPUT jack group. | *b.* Connect patching cord between the INPUT LINE and INPUT EQUIP jacks. If this clears trouble, check jacks and wiring in INPUT jack group, jack J1 through J6. Check wiring between jacks J3 and J4 and terminals 3 and 4 on transformer T4. Check wiring between J1 and J2 and connector J18. |
| | *c.* Defective transformer T4. | *c.* Check transformer T4 (par. 281). |
| | *d.* Failure of LEVEL ADJUST control. | *d.* Check LEVEL ADJUST control AT1 (par. 249). Check wiring between transformer T4 and LEVEL ADJUST control. |
| | *e.* Defective switch S1 | *e.* Check both sections of switch S1. Check wiring between LEVEL ADJUST control and switch S1. |
| | *f.* Defective jack or wiring in OUTPUT jack group. | *f.* Check jacks and wiring in OUTPUT jack group, jacks J11 through J16. Check wiring between switch S1 and jacks J13 and J14. Check wiring between jacks J15 and J16 and connector J18. |
| 2. No transmission through AMPLIFIER A of LEVEL CONTROL & PLATE SUPPLY. | *a.* Failure of B plus to AMPLIFIER A. | *a.* Check fuse F1 and indicator I 1. Check switch S2. Perform trouble isolation tests on plate supply A (PS1) (par. 280). |
| | *b.* Failure of heater voltage | *b.* Check for presence of 6.3 volts ac between terminals 3 and 5 on terminal board TB4 of plate supply PS1 and PS2. If present, check continuity of heater circuit. If absent, perform trouble isolation tests for plate supply PS1 or PS2 (par. 280). |
| | *c.* Failure of AMPLIFIER A. | *c.* Perform trouble isolation tests on line amplifier AR1 (par. 279). |
| | *d.* Defective switch S1 | *d.* Check switch S1. |

| Symptom | Probable trouble | Correction |
|---|---|---|
| 3. No transmission through AMPLIFIER B of LEVEL CONTROL & PLATE SUPPLY. | *a.* Failure of B-plus to AMPLIFIER B. | *a.* Check fuse F2 and indicator I2. Check switch S3. Perform trouble isolation tests on plate supply B (PS2) (par. 280). |
| | *b.* Failure of heater voltage. | *b.* Check for presence of 6.3 volts ac between terminals 3 and 5 on terminal board TB4 of plate supply PS1 and PS2. If present check continuity of heater circuit. If absent perform trouble isolation tests for plate supply PS1 or PS2 (par. 280). |
| | *c.* Failure of AMPLIFIER B. | *c.* Perform trouble isolation tests on line amplifier AR2 (par. 279). |
| | *d.* Defective switch S1. | *d.* Check switch S1. |
| 4. LEVEL CONTROL & PLATE SUPPLY output level out of limits. | *a.* Defective part or wiring in line amplifier in use. | *a.* Perform trouble isolation tests on line amplifier in use (par. 279). |
| | *b.* Defective LEVEL ADJUST. | *b.* Check LEVEL ADJUST control AT1. |
| | *c.* Defective transformer T4. | *c.* Check transformer T4. |

## 278. Trouble Localization, LEVEL CONTROL & PLATE SUPPLY

The general procedure for localizing trouble is described in paragraph 239*c*. To trace trouble in the LEVEL CONTROL & PLATE SUPPLY, it is necessary to test AMPLIFIER A and AMPLIFIER B and also plate supply A and plate supply B. Check also the circuit wiring from multicontact connector J18 to the INPUT LINE and OUTPUT LINE jacks and to contact 2 of switches S2 and

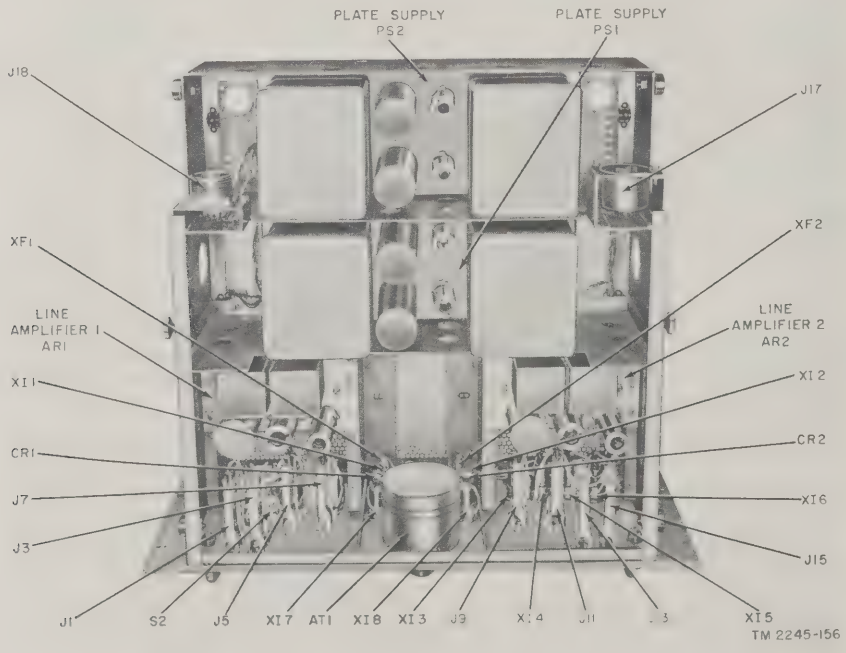



*Figure 196. LEVEL CONTROL & PLATE SUPPLY, top view.*

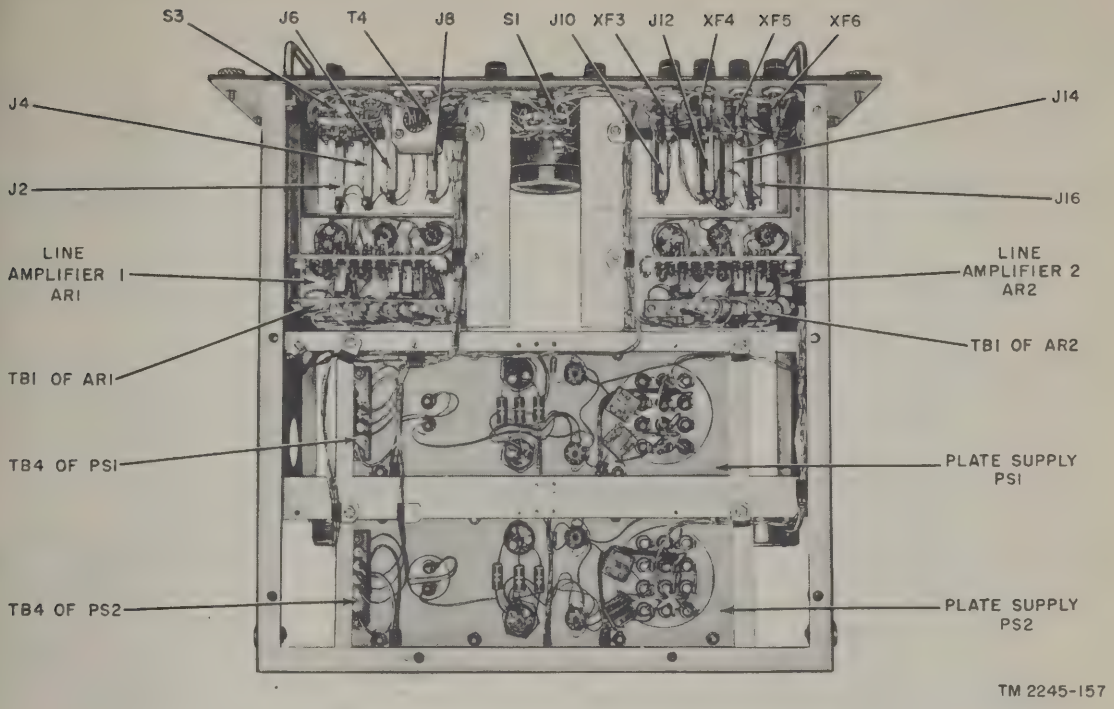



*Figure 197. LEVEL CONTROL & PLATE SUPPLY, bottom view.*

S3. Use Signal Generator SG–15/PCM, Electronic Multimeter ME–6A/U, Multimeter TS–352/U, and the LEVEL METER on the TRANSMITTER METER PANEL as required to perform the tests indicated in *c* below. Trace the circuit paths on the LEVEL CONTROL & PLATE SUPPLY schematic diagram (fig. 104). To check the wiring, refer to the LEVEL CONTROL & PLATE SUPPLY wiring diagram (fig. 278).

*a. Test of LEVEL CONTROL & PLATE SUPPLY, AMPLIFIER A.*

(1) Connect the OUTPUT jacks of the signal generator to the INPUT EQUIP jacks of the LEVEL CONTROL & PLATE SUPPLY.

(2) Adjust the output level of the signal generator to 0 dbm and its frequency to 3,000 cps.

(3) Set the LEVEL ADJUST control in position 10.

(4) Connect the OUTPUT EQUIP jacks of the LEVEL CONTROL & PLATE SUPPLY to the TERMINATING jacks of the LEVEL METER on the TRANSMITTER METER PANEL.

(5) Set the AMPLIFIER IN USE switch to position A.

(6) Set the CHANNELS 1–8 and AMPL A ON POWER SUPPLY switch to the A position, and set the CHANNELS 9–16 and AMPL B ON POWER SUPPLY switch to the B position.

(7) The LEVEL METER should read +10 dbm ±1 dbm. If the reading differs widely from this value, make the localization tests listed in *c* below.

*b. Test of LEVEL CONTROL & PLATE SUPPLY, AMPLIFIER B.*

(1) Make the test setup as indicated in *a* (1) through (4) above.

(2) Set the AMPLIFIER IN USE switch to position B.

(3) The LEVEL METER should read +10 dbm±1 db. If the reading differs widely from this value, make the localization tests listed in *c* below.

*c. Localization Tests, LEVEL CONTROL & PLATE SUPPLY, AMPLIFIER A or AMPLIFIER B.*

| Test No. | Electronic Multimeter ME-6/U probe connections | Normal reading (volts ac) | Corrective measures |
|---|---|---|---|
| 1 | Transformer T4, terminals 1 and 2 (ground). | 0. 75 | Check circuit wiring of INPUT EQUIP and INPUT MONITOR jacks. Check transformer T4 (par. 281). |
| 2 | LEVEL ADJUST control terminals 3 and 2 (ground). | . 0075 | Check LEVEL ADJUST control AT1 (par. 249) and wiring between transformer T4 and LEVEL ADJUST AT1. |
| 3 | Terminal board TB1 of line amplifier A or B, terminals 1 and 2. | . 0075 | Check switch S1, section 1, and wiring to terminals 2 and 3 of LEVEL ADJUST AT1 and to terminals 1 and 2 of terminal board TB1 of amplifier AR1 or AR2. |
| 4 | Terminal board TB1 of line amplifier A or B terminals 3 and 4 (ground). | 2. 5 | Perform trouble isolation tests on line amplifier AR1 or AR2 (par. 279). |
| 5 | Tip connections of OUTPUT EQUIP jacks. | 2. 5 | Check switch S1, section 2, and wiring to terminals 3 and 4 of terminal board TB1 of amplifier AR1 or AR2 and to jacks J13 and J14. |

*d. Test of LEVEL CONTROL & PLATE SUPPLY, Plate Supplies A and B.*

(1) Set CHANNELS 1–8 and AMPL A ON POWER SUPPLY switch to the A position and CHANNELS 9–16 and AMPL B ON POWER SUPPLY switch to the B position.

(2) Measure +200 volts dc at terminals 5 and 8 (ground) of terminal board TB1 in both amplifiers AR1 and AR2, and 6.3 volts ac at terminals 6 and 7 of terminal board TB1. If these voltages are not present or are incorrect, make the localization measurements with Multimeter TS–352/U listed in *e* below.

*e. Localization Tests, LEVEL CONTROL & PLATE SUPPLY, Plate Supply A or B.*

| Test No. | Multimeter TS–352/U probe connection | Normal reading (volts) | Corrective measures |
|---|---|---|---|
| 1 | Transformer T3, of plate supply PS1 or PS2, terminals 1 and 4. | 230 ac | Check fuses F3 and F4 or F5 and F6 and indicators I 3 and I 4 or I 5 and I 6. Check connector J17 and wiring to fuses F3 through F6. |
| 2 | Terminal board TB4, of plate supply PS1 or PS2, terminals 3 and 5. | 6.3 ac | Perform trouble isolation tests on plate supply PS1 or PS2 (par. 280). |
| 3 | Terminal board TB4, of plate supply PS1 or PS2. | +200 dc | Perform trouble isolation tests on plate supply PS1 or PS2 (par. 280). |
| 4 | Terminal board TB1, of line amplifiers AR1 or AR2, terminals 6 and 7. | 6.3 dc | Check switch S2 or S3. |
| 5 | Terminal board TB1, of line amplifier AR1 or AR2, terminals 5 and 8 (ground). | +200 dc | Check switches S2 or S3. Check fuse F1 or F2 and indicator I 1 or I 2. Check indicators I 7 and I 8 and diodes CR1 and CR2. |

## 279. Trouble Isolation, LEVEL CONTROL & PLATE SUPPLY, Line Amplifier AR1 or AR2

(figs. 198–200)

The general procedure to be followed in isolating trouble is discussed in paragraph 239*d*.

*a. Test Setup.* The test setup for isolating trouble in line amplifier AR1 or AR2 is the same as that used for localizing trouble in the LEVEL CONTROL & PLATE SUPPLY (par. 278*a* or *b*, respectively). Usually the trouble isolation tests are made immediately following the localization tests, with the test setup left intact.

*b. Isolation Tests.* To isolate trouble in the line amplifier, make the measurements listed in

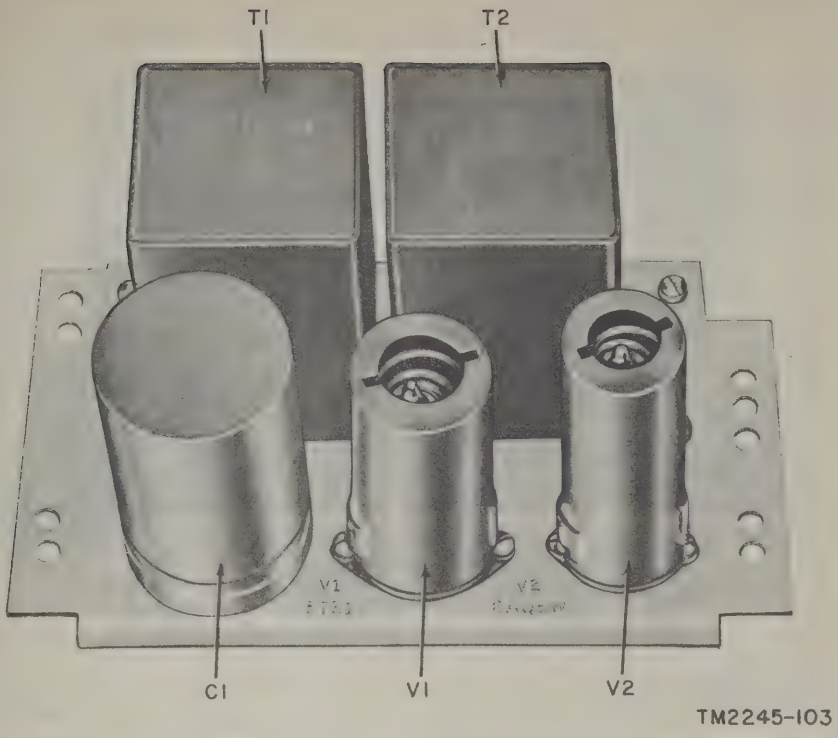



*Figure 198. Line amplifier, top view.*

the following table. At the same time trace the signal path on the line amplifier schematic diagram (fig. 106). To check the wiring, refer to the line amplifier wiring diagram (fig. 279).

| Test No. | Electronic Multimeter ME-6A/U probe connections | Normal reading (volts ac) | Corrective measures |
|---|---|---|---|
| 1 | Transformer T1, terminals 1 and 2 | 0.0075 | Check wiring between terminal board TB1 and transformer T1. |
| 2 | Tube socket XV1, terminal 2 and ground | .01 | Check transformer T1 (par. 281) and wiring. Check resistors R1 and R3. |
| 3 | Tube socket XV1, terminal 1 and ground | .04 | Check tube V1. Measure voltages and resistances at tube socket XV1 (par. 281). |
| 4 | Tube socket XV1, terminal 6 and ground | 1.9 | Measure voltages and resistances at tube socket XV1 (par. 281). Check tube V1, capacitor C3, and interstage wiring. |
| 5 | Tube socket XV2, terminal 5 and ground | 9 | Measure voltages and resistances at tube socket XV2 (par. 281). Check tube V2, capacitors C2, C4, C5, and C6, resistors R2 and R10, and wiring. |
| 6 | Terminal board TB1, terminals 3 and 4 | 2.5 | Check transformer T2 (par. 281) and wiring. |

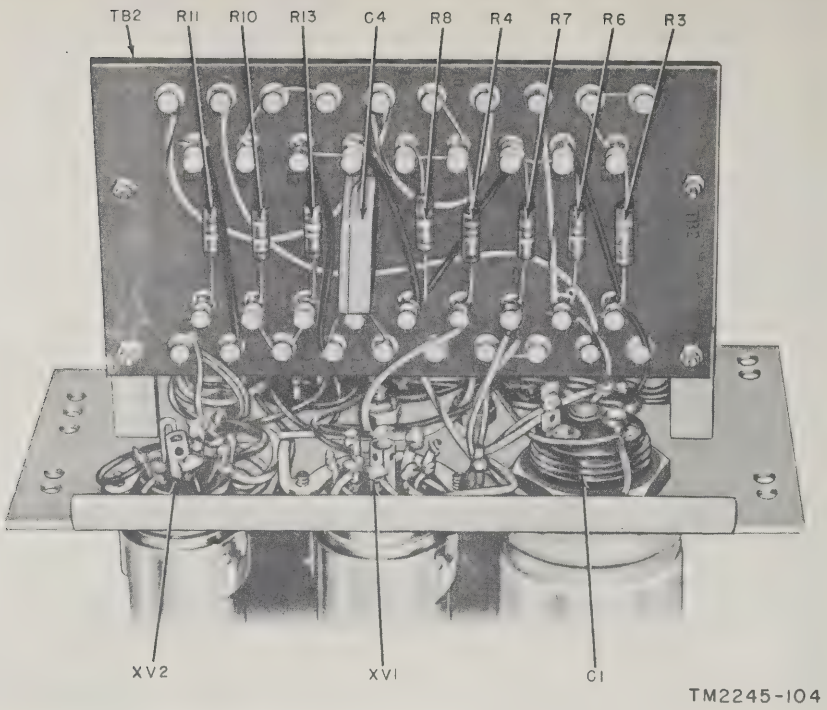



*Figure 199. Line amplifier, bottom view from right side.*

## 280. Trouble Isolation, Plate Supply PS1 or PS2 of LEVEL CONTROL & PLATE SUPPLY

Plate supplies PS1 and PS2 in the LEVEL CONTROL & PLATE SUPPLY are the same as plate supply PS1 in the SUBGROUP MODULATOR. Follow the instructions in paragraph 273 for isolating trouble in either plate supply. Refer to the schematic diagram (fig. 102) and the wiring diagram (fig. 276).

## 281. Additional Trouble-shooting Information, LEVEL CONTROL & PLATE SUPPLY

*a. Typical Resistance Readings.* The resistances of transformers and inductors are measured with all connections removed from their terminals. The resistances at the terminals of tube sockets are measured with the connections intact and all conditions normal, except that the power is disconnected from the equipment. Typical resistance measurements for the LEVEL CONTROL & PLATE SUPPLY are listed in the following chart:

(1) *Line amplifier AR1 or AR2.*

| Item | Measure from terminal | Measure to terminal | Voltage (volts) |
|---|---|---|---|
| Tube sockets: | | | |
| XV1 | 2 | Ground | 900 |
| | 3 | Ground | 686 |
| | 7 | Ground | 1 meg |
| | 8 | Ground | 2, 700 |
| XV2 | 2 | Ground | 336 |
| | 5 | 6 | 100 |
| | 7 | Ground | 470, 000 |
| Transformers: | | | |
| T1 | 1 | 2 | 27. 7 |
| | 3 | 4 | 130 |
| T2 | 1 | 4 | 180 |
| | 5 | 6 | 35. 6 |

(2) *Plate supply PS1 or PS2.* The typical resistance readings for plate supplies PS1 and PS2 in the LEVEL CONTROL & PLATE SUPPLY are the same as those for plate supply PS1 in the SUBGROUP MODULATOR (par. 275*a*).

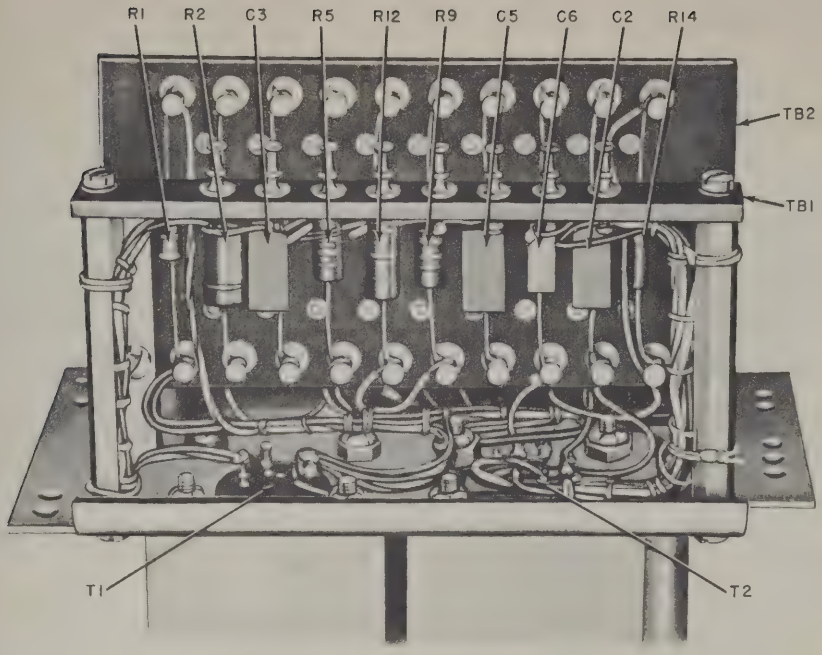



*Figure 200. Line amplifier, bottom view from left side.*

*b. Typical Voltage Readings.* Voltages are measured with the equipment connected to its regular power supply, with tubes in place and all conditions normal. Typical voltage measurements for the LEVEL CONTROL & PLATE SUPPLY are listed in the following chart:

(3) *Line amplifier AR1 or AR2.*

| Item | Measure from terminal | Measure to terminal | Voltage (volts) |
|---|---|---|---|
| Tube sockets: | | | |
| XV1 | 1 | Ground | +63 dc |
| | 3 | Ground | +.65 dc |
| | 4, 5 | 9 | 6.3 ac |
| | 6 | Ground | +90 dc |
| | 8 | Ground | +1.3 dc |
| Tube sockets: | | | |
| XV2 | 2 | Ground | +10.5 dc |
| | 3 | 4 | 6.3 ac |
| | 5 | Ground | +195 dc |
| | 6 | Ground | +195 dc |

(2) *Plate supply PS1 or PS2.* The typical voltage readings for plate supplies PS1 and PS2 in the LEVEL CONTROL & PLATE SUPPLY are the same as those for plate supply PS1 in the SUBGROUP MODULATOR (par. 275*b*).

## Section IX. TROUBLESHOOTING, 3KC SEND BAND TEST PANEL

### 282. Troubleshooting Procedure 3KC SEND BAND TEST PANEL

The 3KC SEND BAND TEST PANEL is composed of four jack group circuits and eight general purpose trunk circuits. When trouble occurs it will generally be known which of these circuits is affected so that it is necessary to check only that particular circuit. Perform the operational test described in paragraph 283, for the circuit involved, to locate the trouble.

## 283. Operational Test, 3KC SEND BAND TEST PANEL

(fig. 201)

The general procedure for making an operational test is given in paragraph 239*b*.

*a. Test Setup.* The 3KC SEND BAND TEST PANEL remains in place in cabinet 1 as installed, but with the suspected jack group or trunk circuit disconnected. Refer to the schematic diagrams of the transmitting terminal (figs. 136 and 137) and of the 3KC SEND BAND TEST PANEL (fig. 139). Use Signal Generator SG–15/PCM in conjunction with the LEVEL METER of the TRANSMITTER METER PANEL for the tests described in *b* and *c* below.

*b. Jack Group Test Procedure.* When a jack group is suspected of being faulty, refer to the schematic diagram of the transmitting terminal and determine which circuit is involved. The input sides (EQUIP OUT jacks) of the jack groups connect to incoming facilities at terminal boards TB106 or TB107 at the rear of cabinet 1. The output sides of the jack groups (LINE IN jacks) connect either to multiplexers or dummy circuit panels. Before performing any tests, isolate the suspected jack group from these external circuits. The procedures for isolating and testing any jack group are outlined in (1) through (11) below.

(1) The EQUIP OUT jacks of JACK GROUP 1 are permanently connected to the output of the telegraph transmitter group of the AN/FGC–29 terminal. To isolate the jack group from this equipment, insert an open twin plug into the OUTPUT LINE jacks of the LEVEL CONTROL & PLATE SUPPLY in cabinet 2. To isolate the EQUIP OUT jacks of JACK GROUP 2, JACK GROUP 3, or JACK GROUP 4, disconnect the associated 3-kc circuit from terminal board TB107 in cabinet 1 as indicated in the following table. Loosen the screws on the terminals and disconnect the conductors:

| Jack group | Terminal board | Terminal pairs |
|---|---|---|
| 2 | TB107 | 1 and 2 |
| 3 | TB107 | 3 and 4 |
| 4 | TB107 | 5 and 6 |

(2) To isolate the LINE IN jacks of JACK GROUP 1 and JACK GROUP 2, disconnect the signal cable to multiplexer No. 1 (or DUMMY CIRCUIT PANEL No. 1) in cabinet 1. To isolate the LINE IN jacks of JACK GROUP 3 and JACK GROUP 4, disconnect the signal cable to multiplexer No. 2 (or DUMMY CIRCUIT PANEL No. 2).

(3) Adjust the frequency of Signal Generator SG–15/PCM to approximately 1,000 cps and the level to 0 dbm.

(4) Connect the signal generator to the terminals on terminal boards TB2 or TB3 (fig. 201) associated with the EQUIP OUT jack pair of the jack group under test as indicated in the following table:

| Jack group | Terminal board | Terminal pairs |
|---|---|---|
| 1 | TB2 | 1 and 2 |
| 2 | TB2 | 5 and 6 |
| 3 | TB3 | 1 and 2 |
| 4 | TB3 | 5 and 6 |

(5) Connect the TERMINATING JACKS of the LEVEL METER to the EQUIP OUT jacks of the jack group under test. The LEVEL METER should read 0 dbm.

(6) Disconnect the LEVEL METER from the EQUIP OUT jacks and connect it to the MONITOR jacks of the same jack group. The LEVEL METER should read 0 dbm.

(7) Momentarily insert an open twin plug successively into the EQUIP OUT and LINE IN jacks. There should be no reading on the LEVEL METER after the plug is inserted.

(8) Connect the signal generator to the terminal associated with the LINE IN jack pair of the jack group under test as indicated in the following table.

| Jack group | Terminal board | Terminal pairs |
|---|---|---|
| 1 | TB2 | 3 and 4 |
| 2 | TB2 | 7 and 8 |
| 3 | TB3 | 3 and 4 |
| 4 | TB3 | 7 and 8 |

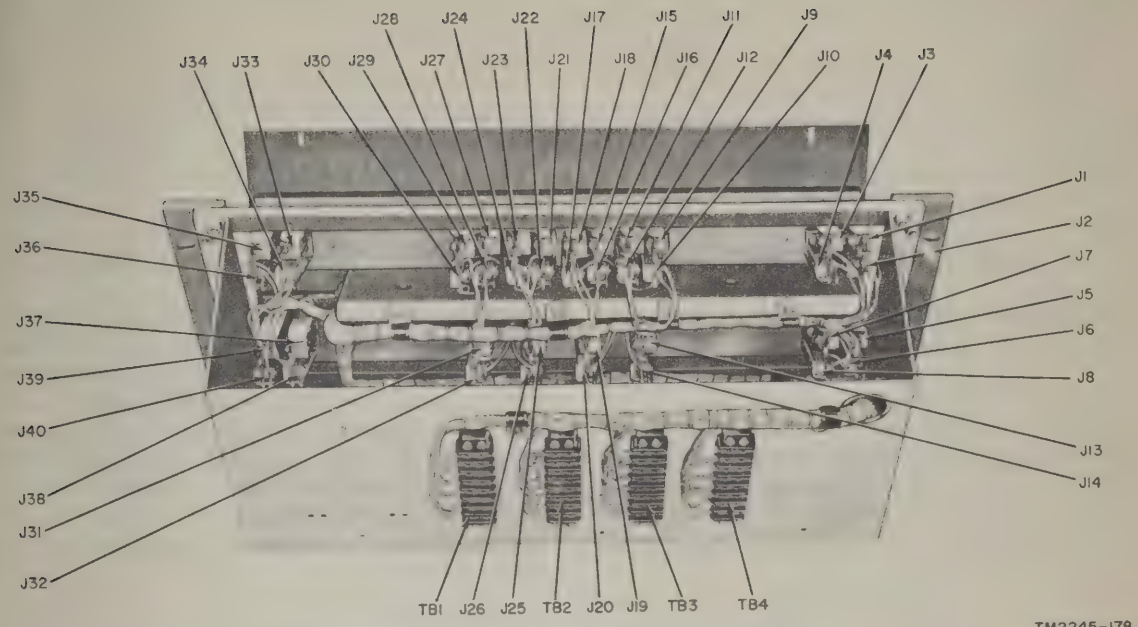



*Figure 201. 3KC SEND BAND TEST PANEL, rear view.*

(9) Connect the LEVEL METER to the LINE IN jacks. The level meter should read 0 dbm.

(10) Disconnect the signal generator and the LEVEL METER and restore the connections which were opened in (1) and (2) above to their normal position.

*c. Trunk Circuit Test Procedure.* When a trunk circuit is suspected of being faulty, disconnect it from any external circuit as described in (1) below. Then perform the tests described in (2) through (5) below:

(1) Isolate the trunk circuit under test from the external circuit by removing the external connections from terminal boards TB103 and TB104 at the rear of cabinet 1 as indicated in the following table. The external circuits associated with these trunks are connected to the terminal boards by means of screws at the top side of the terminals listed in the table below. Loosen the screws on the terminals associated with the trunk circuit involved and disconnect the external wires.

| Trunk | Terminal board | Terminal pairs |
|---|---|---|
| 1 | TB103 | 5 and 6 |
| 2 | TB103 | 7 and 8 |
| 3 | TB103 | 9 and 10 |
| 4 | TB104 | 1 and 2 |
| 5 | TB104 | 3 and 4 |
| 6 | TB104 | 5 and 6 |
| 7 | TB104 | 7 and 8 |
| 8 | TB104 | 9 and 10 |

(2) Adjust the frequency of Signal Generator SG–15/PGM to 1,000 cps and its level to 0 dbm.

(3) Connect the signal generator to the trunk circuit under test at terminal board TB1 or TB4 of the 3KC SEND BAND TEST PANEL as shown in the following table.

| Trunk | Terminal board | Terminal pairs |
|---|---|---|
| 1 | TB1 | 1 and 2 |
| 2 | TB1 | 3 and 4 |
| 3 | TB1 | 5 and 6 |
| 4 | TB1 | 7 and 8 |

| Trunk | Terminal board | Terminal pairs |
|---|---|---|
| 5 | TB4 | 1 and 2 |
| 6 | TB4 | 3 and 4 |
| 7 | TB4 | 5 and 6 |
| 8 | TB4 | 7 and 8 |

(4) Connect the TERMINATING jacks of the LEVEL METER to trunk jack pair associated with the trunk under test. The LEVEL METER should read 0 dbm.

(5) Disconnect the signal generator and the LEVEL METER. Restore the connections which were removed from terminal boards TB103 or TB104 in (1) above.

## Section X. TROUBLESHOOTING, TRANSFORMER ASSEMBLY TF–206/FG

### 284. Operational Test, Transformer Assembly TF–206/FG

(figs. 202 and 203)

Transformer Assembly TF–206/FG is composed of four separate line-coupling transformers. When trouble is suspected in a transformer, check the particular transformer circuit.

*a. Test Setup.* The transformer assembly remains in place as installed, except that the suspected faulty transformer is disconnected from the external lines and equipment. To determine which transformer circuit is involved, refer to the schematic diagrams of the transmitting terminal (figs. 136 and 137) or receiving terminal (figs. 252 and 253) and the results of the sectionalizing tests in paragraphs 256 and 257. When it has been determined which transformer is in the faulty

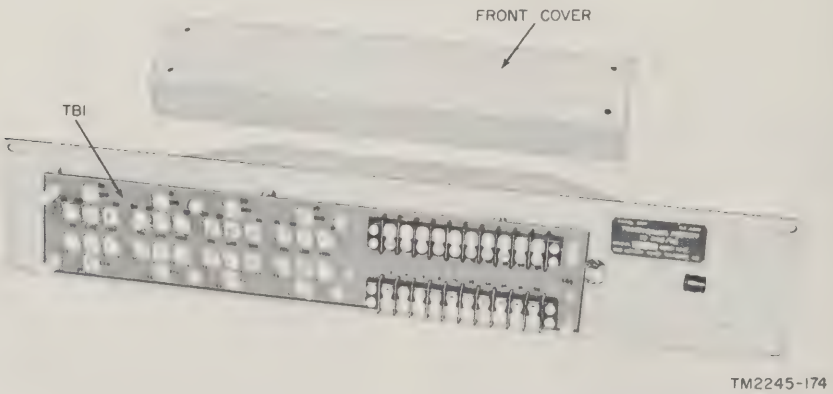



*Figure 202. Transformer Assembly TF–202/FG, front view, cover removed.*

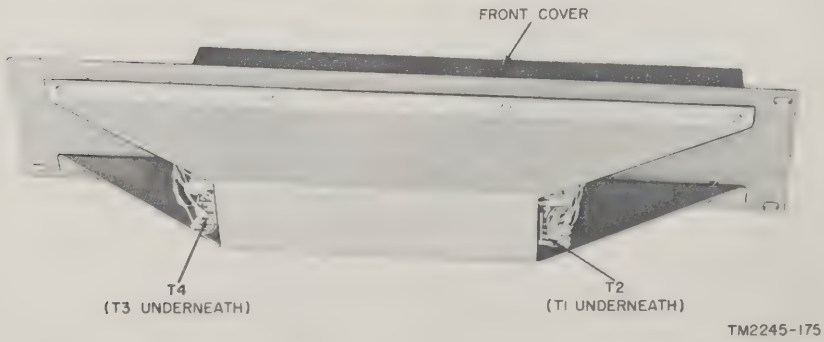



*Figure 203. Transformer Assembly TF–206/FG, rear view.*

circuit, disconnect it from the external circuits and perform the tests described in *b* below. Signal Generator SG–15/PCM and Electronic Multimeter ME–6A/U are required for this test. Refer to the Transformer Assembly TF–206/FG schematic diagram (fig. 138). To check the actual wiring, refer to the wiring diagram (fig. 288).

*b. Test Procedure.* Disconnect the external wires from the suspected circuit as described in (1) below and make the tests described in (2) through (7) below.

(1) The following table lists the five external connections which must be removed from each transformer circuit before performing the tests described below. To reach these connections remove the front cover panel from the transformer assembly (fig. 202).

| Transformer | Disconnect external wires from terminal board TB1 terminals |
|---|---|
| T1 | 1–2, 9–10, 17 |
| T2 | 3–4, 11–12, 18 |
| T3 | 5–6, 13–14, 19 |
| T4 | 7–8, 15–16, 20 |

(2) Adjust the frequency of the signal generator to 1,000 cps and its output to 1.0 volt as measured on the multimeter. Connect the signal generator and multimeter to the circuit under test in accordance with the following table.

| Transformer circuit | Connect signal generator to terminal board TB1 terminals | Connect multimeter to terminal board TB1 terminals |
|---|---|---|
| T1 | 9 and 10 | 1 and 2 |
| T2 | 11 and 12 | 3 and 4 |
| T3 | 13 and 14 | 5 and 6 |
| T4 | 15 and 16 | 7 and 8 |

(3) With the signal generator and electronic multimeter connected as described in (2) above, connect the terminal links on terminal board TB1 in accordance with the following table. The indicated readings should be obtained. Before changing the terminal links make a record of their original positions.

| Transformer circuit | Connect terminal links between terminal board TB1 terminals | Multimeter reading (volts) |
|---|---|---|
| T1 | 24 and 21, 25 and 22 | 0.5±0.05 |
| | 24 and 23, 25 and 26 | 1.0± .1 |
| | 24 and 27, 25 and 28 | 1.5± .15 |
| T2 | 32 and 29, 33 and 30 | .5± .05 |
| | 32 and 31, 33 and 34 | 1.0± .1 |
| | 32 and 35, 33 and 36 | 1.5± .15 |
| T3 | 40 and 37, 41 and 38 | .5± .05 |
| | 40 and 39, 41 and 42 | 1.0± .1 |
| | 40 and 43, 41 and 44 | 1.5± .15 |
| T4 | 48 and 45, 49 and 46 | .5± .05 |
| | 48 and 47, 49 and 50 | 1.0± .1 |
| | 48 and 51, 49 and 52 | 1.5± .15 |

(4) Check the simplex circuit of the suspected transformer by making the connection listed in the following table with the signal generator connected as in (2) above.

| Transformer circuit | Connect terminal links between terminal board TB1 terminals | Connect multimeter to terminal board TB1 terminals | Multimeter reading (volts) |
|---|---|---|---|
| T1 | 24–27 | 1 and 17 | 0.75±0.075 |
| T2 | 32–35 | 3 and 18 | .75± .075 |
| T3 | 40–43 | 5 and 19 | .75± .075 |
| T4 | 48–51 | 7 and 20 | .75± .075 |

(5) Disconnect the signal generator and multimeter from terminal board TB1.

(6) Restore the terminal links on terminal board TB1 to the original position ((3) above).

(7) Restore the connections which were removed ((1) above).

## 285. Additional Troubleshooting Information, Transformer Assembly TF–206/FG

Measure the resistances of the transformers in Transformer Assembly TB–206/FG with all connections removed from their terminals. Typical resistance measurements are given in the table below.

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Transformers T1 through T4 | 1 | 2 | 14.4 |
| | 3 | 4 | 14.4 |
| | 5 | 8 | 31.7 |
| | 9 | 12 | 31.7 |

## 286. Troubleshooting Procedures, 3KC RECEIVE BAND TEST PANEL

(fig. 204)

The 3KC RECEIVE BAND TEST PANEL is composed of eight jack group and eight general purpose trunk circuits. To locate trouble in this panel, perform the operational test described in paragraph 287 for the circuit involved.

## 287. Operational Test, 3KC RECEIVE BAND TEST PANEL

(fig. 204)

The general procedure for making an operational test is given in paragraph 239*b*. Operational test procedures for the 3KC RECEIVE BAND TEST PANEL are described in *a* through *c* below.

*a. Test Setup.* The 3KC RECEIVE BAND TEST PANEL remains in place in cabinet 3 as installed, but with the suspected jack group or trunk circuit disconnected. Refer to the schematic diagrams of the receiving terminal (figs. 252 and 253) and the 3KC RECEIVE BAND TEST PANEL (fig. 140). Use Signal Generator SG–15/PCM in conjunction with the LEVEL METER of the RECEIVER METER PANEL as described in *b* and *c* below.

*b. Jack Group Test Procedure.* When a jack group is suspected of being faulty, refer to the schematic diagram of the receiving terminal and determine which circuit is involved. The component which immediately precedes the LINE OUT jacks in the signal path will be either Demultiplexer TD–98/FGR–3, Audio Frequency Amplifier AM–911/FG, or a DUMMY CIRCUIT PANEL, depending on the system application of the AN/FGC–29 terminal. The EQUIP IN jacks of the 3KC RECEIVE BAND TEST PANEL connect to 3 kc terminal equipment circuits on terminal boards TB107 or TB108 at the rear of cabinet 3. Before performing any tests, isolate the suspected jack group from these external circuits. Subparagraphs (1) through (11) below describes the procedure for isolating and testing any jack group.

(1) Perform the operation described in (*a*) below if the LINE OUT jacks of the jack group connect to a demultiplexer, in (*b*) below if they connect to an audio frequency amplifier, and in (*c*) below if they connect to a DUMMY CIRCUIT PANEL.

(*a*) Insert an open twin plug into the OUTPUT LINE jacks of the demultiplexer circuit (direct path or translated path) connected to the jack group under test.

(*b*) Insert an open twin plug into the OUTPUT LINE jacks of the audio frequency amplifier circuit (AMPLIFIER A or AMPLIFIER B) connected to the jack group under test.

(*c*) Disconnect the signal cable from connector J2 on the DUMMY CIRCUIT PANEL. This will isolate the LINE OUT jacks of two jack groups.

(2) Disconnect the EQUIP IN jacks from their associated 3–kc terminal equipment. To do this, loosen the screw terminals on the bottom side of the appropriate terminals on terminal board TB107 or TB108 in cabinet 3. Remove the wires from the terminals indicated in the following chart.

| Jack group | Terminal board | Terminal pairs |
|---|---|---|
| 1 | TB107 | 5 and 6 |
| 2 | TB107 | 7 and 8 |
| 3 | TB107 | 9 and 10 |
| 4 | TB108 | 1 and 2 |
| 5 | TB108 | 3 and 4 |
| 6 | TB108 | 5 and 6 |
| 7 | TB108 | 7 and 8 |
| 8 | TB108 | 9 and 10 |

(3) Adjust the frequency of Signal Generator SG–15/PCM to 1,000 cps with the level at 0 dbm.

(4) Supply the signal from the signal generator to the LINE OUT jacks of the jack group under test. To do this, connect the signal generator between the terminals at the rear of the 3KC RECEIVE BAND TEST PANEL as indicated in the following table.

| Jack group | Terminal board | Terminal pairs |
|---|---|---|
| 1 | TB2 | 3 and 4 |
| 2 | TB2 | 7 and 8 |
| 3 | TB3 | 3 and 4 |
| 4 | TB3 | 7 and 8 |
| 5 | TB4 | 3 and 4 |
| 6 | TB4 | 7 and 8 |
| 7 | TB5 | 3 and 4 |
| 8 | TB5 | 7 and 8 |

(5) Connect the TERMINATING jacks of the LEVEL METER to the LINE OUT jacks of the jack group under test. The LEVEL METER should read 0 dbm.

(6) Disconnect the LEVEL METER from the LINE OUT jacks and connect it to the MONITOR jacks of the same jack group. The LEVEL METER should read 0 dbm.

(7) Momentarily insert an open twin plug successively into the LINE OUT jacks and the EQUIP IN jacks. There should be no reading on the LEVEL METER after the plug is inserted.

(8) Connect the signal generator to the terminals associated with the EQUIP IN jack pair of the jack group under test as indicated in the following chart.

| Jack group | Terminal board | Terminal pairs |
|---|---|---|
| 1 | TB2 | 1 and 2 |
| 2 | TB2 | 5 and 6 |
| 3 | TB3 | 1 and 2 |
| 4 | TB3 | 5 and 6 |
| 5 | TB4 | 1 and 2 |
| 6 | TB4 | 5 and 6 |
| 7 | TB5 | 1 and 2 |
| 8 | TB5 | 5 and 6 |

(9) Disconnect the LEVEL METER from the MONITOR jacks and connect it to the EQUIP IN jacks. The meter should read 0 dbm.

(10) Disconnect the signal generator and the LEVEL METER. Restore all connections which were opened ((1) and (2) above), to their normal positions.

*c. Trunk Circuit Test Procedure.* When a trunk circuit is suspected of being faulty, disconnect it from an external circuit as described in (1) below. Then perform the tests described (2) through (5) below:

(1) Isolate the trunk circuit under test from the external circuit by removing the external connectors from terminal boards TB 103 and TB104 at the rear of cabinet 3. The external circuits associated with these trunks are connected to terminal boards by means of screws at the top side of the terminals listed in the chart below. Loosen the screws on the terminals associated with the trunk circuit involved and disconnect the external wires.

| Trunk circuit | Terminal board | Terminals |
|---|---|---|
| 1 | TB103 | 5 and 6 |
| 2 | TB103 | 7 and 8 |
| 3 | TB303 | 9 and 10 |
| 4 | TB104 | 1 and 2 |
| 5 | TB104 | 3 and 4 |
| 6 | TB104 | 5 and 6 |
| 7 | TB104 | 7 and 8 |
| 8 | TB104 | 9 and 10 |

(2) Adjust the frequency of Signal Generator SG–15/PCM to 1,000 cps and its level to 0 dbm.

(3) Connect the signal generator to the trunk circuit under test at terminal board TB1 or TB6 of the 3KC RECEIVE BAND TEST PANEL as shown in the following chart.

| Trunk circuit | Terminal board | Terminals |
|---|---|---|
| 1 | TB1 | 1 and 2 |
| 2 | TB1 | 3 and 4 |
| 3 | TB1 | 5 and 6 |
| 4 | TB1 | 7 and 8 |
| 5 | TB6 | 1 and 2 |
| 6 | TB6 | 3 and 4 |
| 7 | TB6 | 5 and 6 |
| 8 | TB6 | 7 and 8 |

(4) Connect the TERMINATING jacks of the LEVEL METER to the trunk jack

pair associated with the trunk under test. The LEVEL METER should read 0 dbm.

(5) Disconnect the signal generator and the LEVEL METER. Restore the connections which were removed from terminal boards TB103 or TB104 ((1) above).

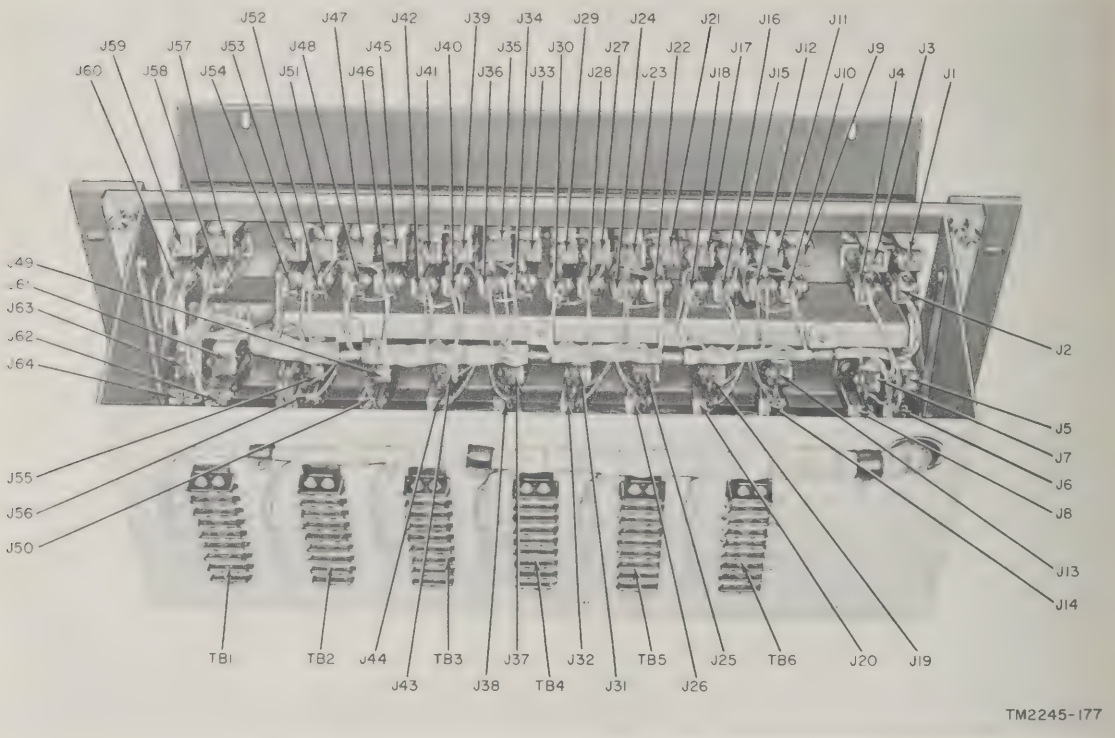



*Figure 204. 3KC RECEIVE BAND TEST PANEL, rear view.*

## Section XII. TROUBLESHOOTING, SUBGROUP DEMODULATOR

### 288. Operational Test, SUBGROUP DEMODULATOR

The general procedure to be followed in performing an operational test is described in paragraph 239*b*. To test a SUBGROUP DEMODULATOR it will be necessary to check the performance of both the direct path and the translated path.

*a. Test Setup.* The SUBGROUP DEMODULATOR remains connected to its regular power supply as installed. Signal Generator SG–15/PCM, Electronic Multimeter ME–6A/U, and Frequency Meter FR–67/U or Frequency Counter AN/USM–26 are required for this test. The necessary connections are described in *b* and *c* below. OUTPUT jacks are not provided on the SUBGROUP DEMODULATOR; make the required measurements at the receiver LINE jacks as described in *b* and *c* below.

*b. Direct Path.* To check the performance of the direct path of the SUBGROUP DEMODULATOR, proceed as follows:

(1) Connect Signal Generator SG–15/PCM to the INPUT EQUIP jacks of the SUBGROUP DEMODULATOR. Adjust the frequency of the signal generator to 2,465 cps $\pm 5$ cps and its output level to 0 dbm.

(2) Connect Electronic Multimeter ME–6A/U to the LINE jacks of RECEIVER CHANNEL 9. (Use RECEIVER A jacks when testing SUBGROUP DEMODULATOR A and RECEIVER B jacks when testing SUBGROUP DE-

MODULATOR B.) The meter should read between .30 and .58 volt.

*Note.* If a correct reading is not obtained at this point, remove the signal cable from connector J23 at the rear of the SUBGROUP DEMODULATOR and connect the electronic multimeter between pin G and ground. The meter should read between .30 and .46 volt. If a correct reading is still not obtained, refer to the troubleshooting chart (par. 289). Replace the signal cable.

*c. Translated Path.* To check the performance of the translated path of the SUBGROUP DEMODULATOR, proceed as follows:

(1) Connect the signal generator to the INPUT EQUIP jacks of the SUBGROUP DEMODULATOR and Frequency Meter FR–67/U or Frequency Counter AN/USM–26 to the INPUT MONITOR jacks. Adjust the signal generator frequency to 935 cps as indicated by the frequency meter and its level to 0 dbm. Record the exact frequency reading.

(2) Connect the electronic multimeter to the LINE jacks of RECEIVER CHANNEL 8. (Use RECEIVER A jacks when testing SUBGROUP DEMODULATOR A and RECEIVER B jacks when testing SUBGROUP DEMODULATOR B.) The meter should read between .30 and .58 volt.

(3) Disconnect the electronic multimeter from the LINE jacks of RECEIVER CHANNEL 8 and in its place connect the frequency meter. The frequency meter reading plus the reading recorded in (1) above should equal 3,400±1 cps.

(4) Disconnect the frequency meter.

(5) Readjust the frequency of the signal generator to 425±1 cps, at the same time maintaining the output level at 0 dbm.

(6) Connect the electronic multimeter to the INPUT LINE jacks of RECEIVER CHANNEL 2. The meter should read between .30 and .58 volt.

(7) Disconnect the electronic multimeter from RECEIVER CHANNEL 2 and connect it to the INPUT LINE jacks of RECEIVER CHANNEL 16.

(8) Readjust the frequency of the signal generator to 1,615±5 cps, maintaining

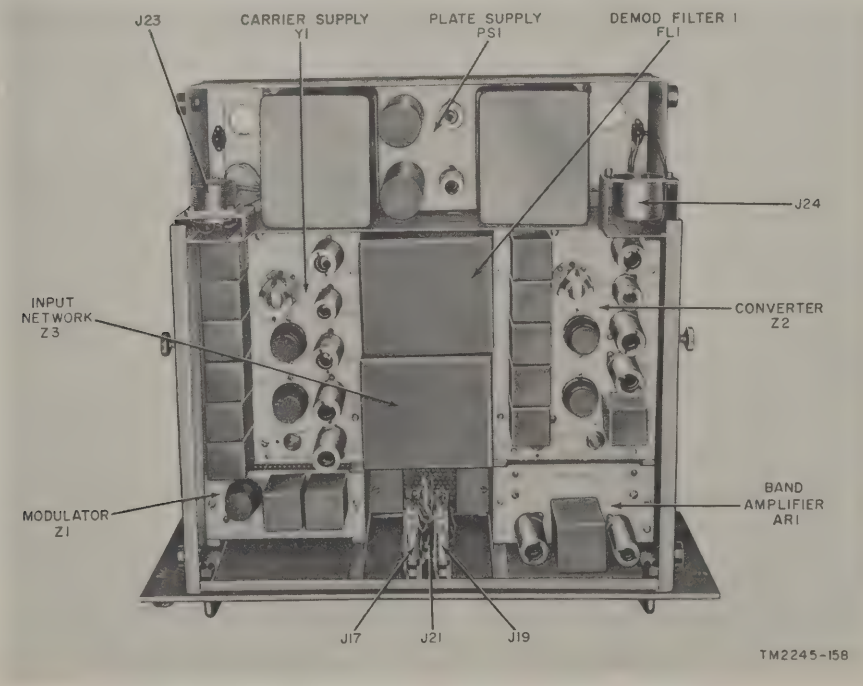



*Figure 205. SUBGROUP DEMODULATOR, top view.*

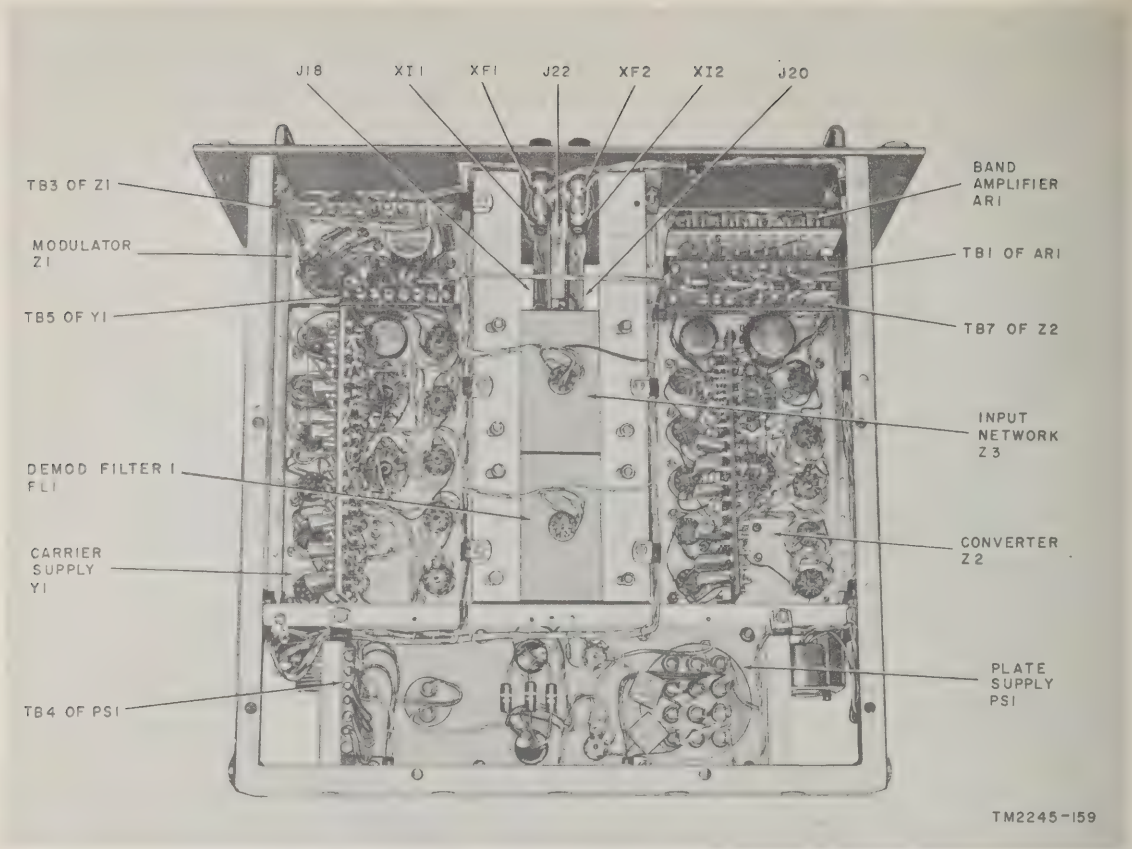



*Figure 206. SUBGROUP DEMODULATOR, bottom view.*

the output level at 0 dbm. The multimeter should read between .30 and .58 volt.

(9) Disconnect the signal generator and the multimeter.

## 289. SUBGROUP DEMODULATOR, Troubleshooting Chart

(figs. 205 and 206)

The following chart is supplied as an aid in locating trouble in the SUBGROUP DEMODULATOR. This chart lists the symptoms which are observed when sectionalizing Telegraph Terminal AN/FGC–29 for trouble. The chart also lists the probable cause of a symptom and gives the localization and isolation procedures to correct it. After the trouble has been localized to a subassembly or circuit in the direct or translated path of the SUBGROUP DEMODULATOR, trouble isolation tests, or voltage and resistance measurements, should be sufficient to locate the trouble. The trouble isolation tests are described in paragraphs 291 and 292. Filter and input network tests are discussed in paragraph 293 and the voltage and resistance measurements are given in paragraph 294. If the troubleshooting chart indicates the specific subassembly or circuit in which the trouble is likely to be found, trouble localization or isolation should begin with the test indicated by the paragraph reference in the *Correction* column. Otherwise, the trouble localization procedures should begin with the first step given in paragraph 290.

| Symptom | Probable trouble | Correction |
|---|---|---|
| 1. No transmission through direct or translated path of SUBGROUP DEMODULATOR. | *a.* Defective jack or wiring in INPUT jack group. | *a.* Connect patching cord between INPUT EQUIP and INPUT LINE jacks. If this clears trouble, check jacks and wiring in INPUT jack group, jacks J17 through J22. |
| | *b.* Defective input network Z3. | *b.* Perform input network tests (par. 293*c*). |
| 2. No transmission through direct path of SUBGROUP DEMODULATOR. | *a.* Defective input network Z3. | *a.* Perform input network tests (par. 293*c*). |
| | *b.* Failure of wiring between terminal 5 of input network Z3 and connector J23, or terminal 6 and ground. | *b.* Check wiring to connector J23, and ground. |
| 3. No transmission through translated path of SUBGROUP DEMODULATOR. | *a.* Failure of ac power supply | *a.* Check ac power source. Check power cord and connections. Check for presence of 230 volts ac between terminals 1 and 4 on transformer T3 of plate supply PS1. Check fuses F1 and F2 and indicator lamps I 1 and I 2. |
| | *b.* Failure of B-plus voltage | *b.* Check for +200 v dc between terminals 1 and 2 of terminal board TB4 of plate supply PS1. If absent, perform trouble isolation test for plate supply PS1 (par. 292). If present, check power circuit continuity. |
| | *c.* Failure of heater voltage | *c.* Check for 6.3 v ac between terminals 3 and 5 of terminal board TB4 of plate supply PS1. If present, check continuity of heater circuit. If absent, perform trouble isolation tests for plate supply, PS1 (par. 292). |
| | *d.* Failure of input network Z3 | *d.* Perform input network tests (par. 293*c*). |
| | *e.* Failure of converter Z2 | *e.* Perform trouble isolation tests on converter Z2 (par. 292). |
| | *f.* Defective demod filter 1 (FL1). | *f.* Check demod filter 1 (FL1) (par. 293*b*). |
| | *g.* Failure of modulator Z1 | *g.* Perform trouble isolation tests on modulator Z1 (par. 292). |
| | *h.* Failure of carrier supply Y1 | *h.* Check for 7.2 v ac between terminals 1 and 2 of terminal board TB5 of carrier supply. If absent, perform trouble isolation tests on carrier supply Y1 (par. 292). |
| | *i.* Failure of band amplifier AR1. | *i.* Perform trouble isolation tests on band amplifier AR1 (par. 291). |
| 4. Direct and translated paths, output levels out of limits. | Defective input coupler Z3 | Perform input network tests (par. 293). |
| 5. Translated path output level out of limits. | *a.* Defective demod filter 1 (FL1). | *a.* Check demod filter 1 (FL1) (par. 293*b*). |
| | *b.* Defective band amplifier AR1. | *b.* Perform trouble isolation tests on band amplifier AR1 (par. 291). |
| 6. Carrier supply output level out of limits. | Defective part in carrier supply Y1. | Check GAIN control R53 of carrier supply Y1 (par. 89*g*). Perform trouble isolation tests for carrier supply Y1 (par. 292). |
| 7. Carrier supply output frequency out of limits. | *a.* Defective crystal Y1 | *a.* Replace crystal Y1. |
| | *b.* Defective part in carrier supply Y1. | *b.* Perform trouble isolation tests for carrier supply Y1 (par. 292). |
| 8. Excessive carrier leak at modulator Z1 output. | *a.* Defective varistor CR1 | *a.* Replace varistor CR1. |
| | *b.* Defective part in modulator Z1. | *b.* Perform trouble isolation tests on modulator (par. 292). |
| 9. Excessive carrier leak at converter Z2 output. | *a.* Defective varistor CR5 | *a.* Replace varistor CR5. |
| | *b.* Defective part in converter Z2. | *b.* Perform trouble isolation tests for converter Z2 (par. 292). |
| 10. Converter output frequency out of limits. | *a.* Defective crystal Y2 | *a.* Replace crystal Y2. |
| | *b.* Defective part in converter Y2. | *b.* Perform trouble isolation for converter Z2 (par. 292). |

## 290. Trouble Localization, SUBGROUP DEMODULATOR

(figs. 205 and 206)

The procedure for localizing trouble is described in paragraph 239*c*. To trace trouble in the SUBGROUP DEMODULATOR it is necessary to test the direct path or the translated path, or both. To localize trouble in the direct path, follow the procedures given in *a* and *b* below and in the translated path, follow the procedures *c* and *d* below. Trace the signal paths on the SUBGROUP DEMODULATOR schematic diagram (fig. 109). To check the actual wiring, refer to wiring diagram for the SUBGROUP DEMODULATOR (fig. 280).

*a. Test Setup, Direct Path.*

(1) Connect the OUTPUT jacks of the Signal Generator SG–15/PCM to the INPUT EQUIP jacks of the SUBGROUP DEMODULATOR.

(2) Connect the LINE jacks of RECEIVER CHANNEL 7 (associated with the SUBGROUP DEMODULATOR being tested) to the INPUT jacks of Electronic Multimeter ME–6A/U.

*b. Localization Tests, Direct Path.*

(1) Adjust the output level of the signal generator to 0 dbm and the frequency to 2,295±1 cps.

(2) The electronic multimeter should read between .30 and .58 volt. If the reading differs widely from this value, proceed with the measurements listed in the chart below.

| Test No. | Electronic multimeter probe connections | Normal reading (volts ac) | Corrective measures |
|---|---|---|---|
| 1 | Input network Z3, terminals 3 and 4 | 0.78 | Check wiring between jacks J17 and J18 and terminals 3 and 4 of input network. |
| 2 | Input network Z3, terminals 5 and 6 (ground). | .35 | Check input network (par. 293). |

*c. Test Setup, Translated Path.*

(1) Connect the OUTPUT jacks of the signal generator to the INPUT EQUIP jacks of the SUBGROUP DEMODULATOR.

(2) Connect the LINE jacks of the RECEIVER CHANNEL 8 associated with the SUBGROUP DEMODULATOR under test to the INPUT jacks of the electronic multimeter.

*d. Localization Tests, Translated Path.*

(1) Adjust the output level of the signal generator to 0 dbm and the frequency to 2,465 cps ±5 cps.

(2) The electronic multimeter should read between .30 and .58 volt. If the reading differs widely from this value, proceed with the measurements listed in the chart below.

| Test No. | Electronic multimeter probe connections | Normal reading (volts ac) | Corrective measures |
|---|---|---|---|
| 1 | Input network Z3, terminals 3 and 4 | 0.78 | Check wiring between jacks J17 and J18 and terminals 3 and 4 of input network Z3. |
| 2 | Input network Z3, terminals 7 and 8 | .078 | Check input network Z3 (par. 293). |
| 3 | Terminal board TB7 of converter Z2, terminals 3 and 4 (ground). | .20 | Check wiring between terminals 7 and 8 of input network Z3 and terminals 1 and 2 of terminal board TB7. Check converter Z3 (par. 292). |
| 4 | Demod filter 1 (FL1), terminals 3 and 4 (ground). | .076 | Check wiring between terminals 3 and 4 of terminal board TB7 and terminals 1 and 2 of demod filter 1. Check demod filter 1 (par. 293). |
| 5 | Terminal board TB3 of modulator Z1, terminals 3 and 4 (ground). | .057 | Check wiring between terminals 3 and 4 of demod filter 1 and terminals 1 and 2 of terminal board TB3. Check equalizer between terminals 1 and 2 of input network Z3 (par. 293). Check modulator Z1 (par. 292). |
| 6 | Terminal board TB1 of modulator Z1, terminals 5 and 6 (ground). | 7.2 | Check wiring between terminals 1 and 2 of TB5 and terminals 5 and 6 of terminal board TB3. Check carrier supply Y1 (par. 292). |
| 7 | Terminal board TB1 of band amplifier AR1, terminals 3 and 4 (ground). | .46 | Check wiring between terminals 3 and 4 of terminal board TB3 and terminals 1 and 2 of terminal board TB1. Check band amplifier AR1 (par. 291). |

## 291. Trouble Isolation, Band Amplifier AR1 of SUBGROUP DEMODULATOR

(figs. 207 and 208)

The general procedure to be followed in isolating trouble is discussed in paragraph 239*d*.

*a. Test Setup.* The test setup for isolating trouble in band amplifier AR1 is the same as that used for localizing trouble in the translated path of the SUBGROUP DEMODULATOR (par. 290). Usually the trouble isolation tests are made immediately following the localization tests, with the test setup left intact.

*b. Isolation Tests.* To isolate trouble in the band amplifier make the measurements listed in the table below. At the same time, trace the signal path in the band amplifier schematic diagram (fig. 111). To check the actual wiring, refer to the band amplifier wiring diagram (fig. 281).

| Test No. | Electronic Multimeter ME-6A/U probe connections | Normal reading (volts ac) | Corrective measures |
|---|---|---|---|
| 1 | Tube socket XV1, terminal 2 and ground | 0.014 | Check wiring between terminal board TB1 and resistor R1 and tube socket XV1. Check tube V1. Check resistors R1 and R2. |
| 2 | Tube socket XV1, terminal 7 and ground | .11 | Check tube V1. Measure dc voltages and resistances at tube socket XV1 (par. 294). Check feedback circuit values (resistors R2, R3, and R12, capacitors C6 and C1). Check capacitor C2 and resistor R4. |
| 3 | Tube socket XV2, terminal 1 and ground | .23 | Check tubes V1 and V2. Measure dc voltages and resistances at tube sockets XV1 and XV2 (par. 294). Check capacitors C3, C4, and C5. Check resistors R7, R8, R9, and R10. |
| 4 | Transformer T1, terminal 1 and ground | 1.2 | Check tube V2. Measure dc voltages and resistances at tube socket XV2 (par. 294). Check transformer T1 (par. 294*a*). |
| 5 | Terminal band TB1, terminals 3 and 4 | .46 | Check transformer T1 (par. 294*a*) and wiring between terminal board TB1 and transformer T1. |

## 292. Trouble Isolation, SUBGROUP DEMODULATOR, Modulator Z1, Carrier Supply Y1, and Plate Supply PS1.

The trouble isolation procedure for the converter, modulator, carrier supply, and plate supply of the SUBGROUP DEMODULATOR are identical with the procedure for the same units of the SUBGROUP MODULATOR. The procedure for the converter is described in paragraph 270, for the modulator in paragraph 271, for the carrier supply in paragraph 272, and for the plate supply in paragraph 273.

## 293. SUBGROUP DEMODULATOR, Demod Filter 1, and Input Network Z3, tests

Demod filter 1 and input network Z3 are nonrepairable sealed units which must be replaced if found to be defective. Test these units by measuring the transmission characteristics at specified frequencies with the units removed from the SUBGROUP DEMODULATOR circuit. Measure also the resistance between terminals.

*a. Test Equipment Required.* The test equipment required to test the demod filter and input network consists of Signal Generator SG–15/PCM, Frequency Meter FR–67/U or Frequency Counter AN/USM–26, and Electronic Multimeter ME–6A/U. The signal generator provides the input signal, and the frequency meter provides accurate measurement of the test frequency. The electronic multimeter measures the input and output voltages.

*b. Tests for Demod Filter 1.*

(1) *Connections.* The connections for testing demod filter 1 are shown at A, figure 193. Make the connections described in (*a*) through (*e*) below.

(*a*) Connect one output terminal of the signal generator to terminal 1 of the filter through a 10,000-ohm, ½-watt resistor.

(*b*) Connect the second output terminal of the signal generator to terminal 2 of the filter.

(*c*) Connect terminal 2 of the filter to ground.

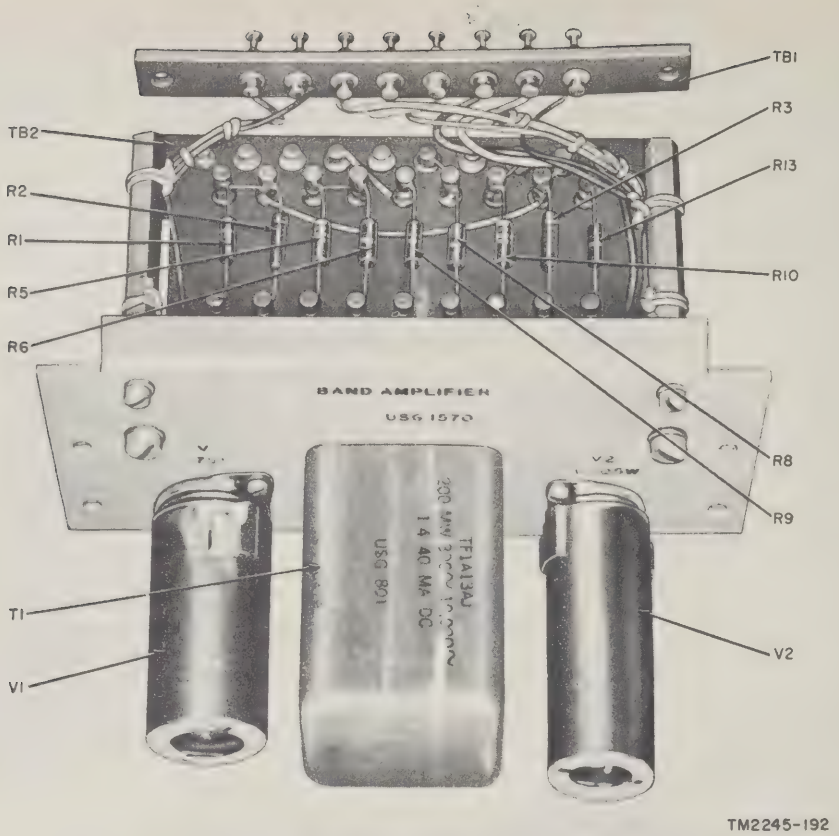
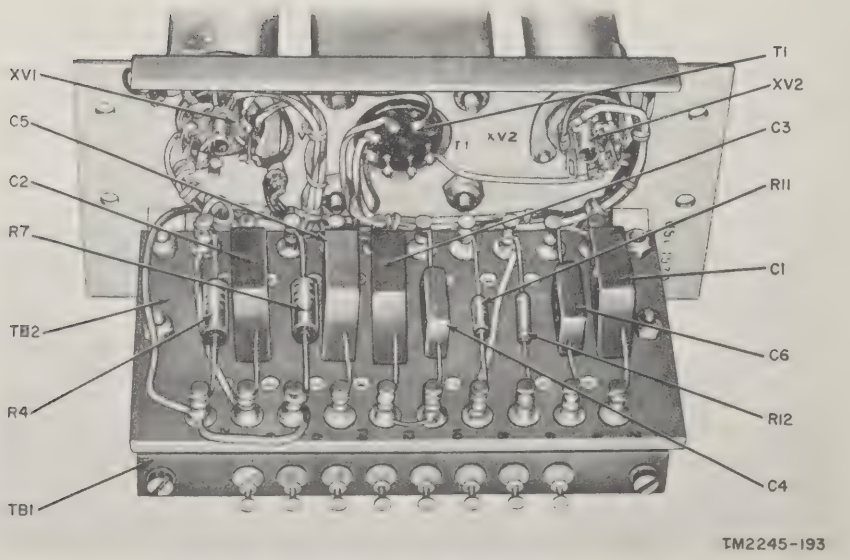



*Figure 207. Band amplifier, top view.*




*Fignre 208. Band amplifier, bottom view from right side.*

(*d*) Connect the input leads of the frequency meter to the output terminals of the signal generator.

(*e*) Connect a 10,000-ohm, ½-watt resistor between terminals 3 and 4 of the filter.

(2) *Measurements.* Use the procedure given in (*a*) through (*f*) below to make the test measurements on demod filter 1.

(*a*) Connect the electronic multimeter to the output terminals of the signal generator.

(*b*) Adjust the output frequency of the signal generator to the frequency specified for test 1 in (3) below. For accurate frequency adjustment, use the frequency meter rather than the reading of the frequency selection dial on the signal generator.

(*c*) Adjust the signal generator output voltage E1 ((3) below).

(*d*) Disconnect the multimeter from the signal generator and connect it between the output terminals of the filter.

(*e*) Measure the filter output voltage (voltage E2 (3) below).

(*f*) Repeat the procedure given in (*a*) through (*e*) above for each frequency listed in the chart below.

(3) *Normal readings, demod filter 1.* Demod filter 1 is acceptable for use if voltage readings E2 in tests 1 through 11 in the table below fall within the limits listed.

| Test No. | Frequency (cps) | E1 (volts) | E2 (volts) |
|---|---|---|---|
| 1 | 4,500 | 7. 75 | 0. 002 max |
| 2 | 5,000 | 7. 75 | . 004 max |
| 3 | 6,000 | 7. 75 | . 015 max |
| 4 | 6,300 | 7. 75 | . 004 max |
| 5 | 6,700 | 7. 75 | . 977 min |
| 6 | 7,000 through 9,000 | 7. 75 | 1. 23 min |
| 7 | 9,300 | 7. 75 | . 977 min |
| 8 | 9,800 | 7. 75 | . 012 max |
| 9 | 9,850 through 10,000 | 7. 75 | . 007 max |
| 10 | 10,900 | 7. 75 | . 012 max |
| 11 | 12,000 through 15,000 | 7. 75 | . 015 max |

*c. Tests for Input Network Z3.*

(1) *Equalizer test.* The equalizer portion of the input network is brought out at terminals 1 and 2 which are connected for testing as shown at B, figure 193. Make the connections and perform the tests described in (*a*) through (*i*) below.

(*a*) Connect one output terminal of the signal generator to terminal 1 of the input network through a 10,000-ohm, ½-watt resistor.

(*b*) Connect the second output terminal of the signal generator to terminal 2 of the input network.

(*c*) Connect terminal 2 of the input network to ground.

(*d*) Connect the input leads of the frequency meter to the output terminals of the signal generator.

(*e*) Connect a 10,000-ohm, ½-watt resistor between terminals 1 and 2 of the input network.

(*f*) Connect the electronic multimeter to the output of the signal generator.

(*g*) Adjust the frequency of the signal generator to 9,300 cps, as indicated by the frequency meter, and the output voltage (E1) to 2.5 volts as indicated by the electronic multimeter.

(*h*) Disconnect the multimeter from the signal generator and connect it across terminals 1 and 2 of the input network.

(*i*) The voltage (E2) indicated on the multimeter should be between 1.14 and 1.22 volts.

(2) *Transmission test.* The transmission paths of the input network are connected for testing as shown at C, figure 193. Make the connections and perform the tests described in (*a*) through (*m*) below.

(*a*) Connect one output terminal of the signal generator through a 600-ohm resistor to terminal 3 of the input network.

(*b*) Connect the second output terminal of the signal generator to terminal 4 of the input network.

(*c*) Connect terminals 4, 6, and 8 of the input network to ground.

(*d*) Connect the input leads of the frequency meter to the output leads of the signal generator.

(*e*) Connect one 600-ohm, ½-watt resistor between terminals 5 and 6 of the input network and a second 600-ohm resistor between terminals 7 and 8.

(*f*) Connect the electronic multimeter to the output terminals of the signal generator.

(*g*) Adjust the frequency of the signal generator to 1,000 cps as indicated on the frequency meter, and the output voltage (E1) to 1.55 volts as indicated on the electronic multimeter.

(*h*) Disconnect the electronic multimeter from the signal generator and connect it between terminals 5 and 6 of the input network.

(*i*) The voltage (E2) indicated on the multimeter should be between .683 and .723 volt.

(*j*) Disconnect the multimeter from terminals 5 and 6 and connect it between terminals 7 and 8.

(*k*) Voltage E3 should read between 0.110 and 0.123 volt. Record the exact reading.

(*l*) Change the frequency of the signal generator to 1,780 cps.

(*m*) The voltage (E3) indicated on the multimeter should fall between 73 percent and 77 percent of the reading recorded in (*k*) above.

## 294. Additional Troubleshooting Information, SUBGROUP DEMODULATOR

*a. Typical Resistance Readings.* Measure the resistances of transformers, filters, and the input network with all connections removed from their terminals. Measure the resistance at the terminals of tube sockets with the connections intact and all conditions normal, except that the power is disconnected from the equipment. Typical resistance readings for the converter, modulator, carrier supply and plate supply of the SUBGROUP DEMODULATOR are the same as for the identical units in the SUBGROUP MODULATOR (par. 275). A table of typical resistance measurements for the band amplifier of the SUBGROUP DEMODULATOR is given in (1) below, for demod filter 1 in (2) below, and for the input network (3) below.

(1) *Band amplifier AR1.*

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Transformer T1 | 1 | 2 | 89 |
| | 3 | 4 | 89 |
| | 5 | 6 | 35 |
| Tube sockets: | | | |
| XV1 | 2 | Ground | 2, 200 |
| | 3 | Ground | 50 |
| | 7 | Ground | 470, 000 |
| | 8 | Ground | 1, 500 |
| XV2 | 1 | Ground | 470, 000 |
| | 2 | Ground | 320 |

(2) *Demod filter 1.*

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Filter FL1 | 1 | 2 | 7, 200 |
| | 2 | 4 | 0 |
| | 3 | 4 | 17 |
| | 1 | 3 | 7, 300 |

(3) *Input network Z3.*

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Input network Z3 | 1 | 2 | 27, 000 |
| | 3 | 4 | 25 |
| | 5 | 6 | 25 |
| | 7 | 8 | 310 |

*b. Typical Voltage Readings.* Voltages are measured with the equipment connected to its regular power supply with tubes in place and all conditions normal. Typical voltage readings for the converter, carrier supply, and plate supply of the SUBGROUP DEMODULATOR are the same as for the identical units in the SUBGROUP MODULATOR (par. 275). A table of typical voltage measurements for the band amplifier is given below.

| Item | Measure from terminal | Measure to terminal | Voltage (volts) |
|---|---|---|---|
| Tube sockets: | 1 | Ground | +160 dc |
| XV1 | 3, 8 | Ground | +1. 5 dc |
| | 4, 5 | 9 | +6. 3 ac |
| | 6 | Ground | +160 dc |
| XV2 | 2 | Ground | +9 dc |
| | 3 | 4 | 6. 3 ac |
| | 5, 6 | Ground | +190 dc |

## 295. Operational Test, Receiver

The general procedure for performing an operational test is described in paragraph 239*b*. To determine if a receiver is functioning properly, check the performance of both the RECEIVER A and RECEIVER B circuits for fading range, tracking, and ratio squaring characteristics. Before starting the test, note the settings of the DELAY ADJ controls and restore them to these settings after the test is completed.

*a. Test Setup.* The receiver remains in place connected to its normal power supply as installed. Signal Generator SG–15/PCM and Electronic Multimeter ME–6A/U are required in addition to the DIVERSITY ALIGNMENT PANEL and RECEIVER METER PANEL. Set up the equipment as indicated in (1) through (3) below.

(1) Connect the OUTPUT jacks of Signal Generator SG–15/PCM to the ODD NO CHAN INPUT jacks on the DIVERSITY ALIGNMENT PANEL. Adjust the frequency of the signal generator to the center frequency of the receiver under test. Adjust the level of the signal generator to −15 dbm.

(2) Connect the ODD NUMBERED CHANNEL RECEIVER A and RECEIVER B OUTPUT jacks on the DIVERSITY ALIGNMENT PANEL to the RECEIVER A and RECEIVER B EQUIP jacks, respectively, of the receiver under test.

(3) Set the DIVERSITY switch of the associated combiner to the 2 CHANNEL position.

(4) Set both RECEIVER A and RECEIVER B DELAY ADJ controls counterclockwise to zero.

(5) Set the COMMON ATTENUATOR on the DIVERSITY ALIGNMENT PANEL to the 0 position. Turn the ODD NUMBERED CHANNEL RECEIVER A OUTPUT switch to ON and turn all other OUTPUT switches to OFF.

*b. Fading Range Test.* This test, described in (1) through (11) below, checks the performance of RECEIVER A and RECEIVER B over the prescribed range of input signal levels.

(1) Connect the BRIDGING jacks of the LEVEL METER on the RECEIVER METER PANEL to the RECEIVER A MONITOR jacks.

(2) Adjust the RECEIVER A LEVEL ADJ until the LEVEL METER reads −20 dbm.

(3) Connect the LEVEL METER to the RECEIVER B MONITOR jacks.

(4) Turn the ODD NUMBERED CHANNEL RECEIVER A OUTPUT switch on the DIVERSITY ALIGNMENT PANEL to OFF and turn the RECEIVER B OUTPUT switch to ON.

(5) Adjust the RECEIVER B LEVEL ADJ until the LEVEL METER reads −20 dbm.

(6) Connect the BRIDGING jacks of the LEVEL METER to the METER jacks of the receiver.

(7) Set the METER SWITCH on the receiver to the B position. The LEVEL METER should read −22 dbm ±2 db.

(8) Change the COMMON ATTENUATOR on the DIVERSITY ALIGNMENT PANEL to the 40 position. The LEVEL METER reading should not decrease by more than 1.5 db from the reading obtained in (7) above.

(9) Turn the EVEN NUMBERED CHANNEL RECEIVER B OUTPUT switch on the DIVERSITY ALIGNMENT PANEL to OFF and turn the RECEIVER A OUTPUT switch to ON. Set the common attenuator to 0.

(10) Set the METER SWITCH on the receiver to position A. The LEVEL METER should read −22 dbm ±2 db.

(11) Change the COMMON ATTENUATOR on the DIVERSITY ALIGNMENT PANEL to the 40 position. The LEVEL METER reading should not decrease more than 1.5 db from the reading obtained in (10) above.

*c. Tracking Test.* This test, described in (1) through (10) below, checks the alignment of the RECEIVER A and RECEIVER B circuits at various input levels. The same test setup is used as in *b* above.

(1) Set the COMMON ATTENUATOR on the DIVERSITY ALIGNMENT PANEL in the 0 position, the ODD NUMBERED CHANNEL RECEIVER A

and RECEIVER B switches in the ON position, and the EVEN NUMBERED CHANNEL OUTPUT switches in the OFF position.

(2) Check that the level at the MONITOR jacks of RECEIVER A and RECEIVER B is −20 dbm.

(3) Connect the BRIDGING jacks of the LEVEL METER to the METER jacks of the receiver and set the METER SWITCH to A. The meter should read between −20 and −25.5 dbm.

(4) Turn the ODD NUMBERED CHANNEL RECEIVER B switch to the OFF position. The reading on the LEVEL METER should increase between 0 db and 3.5 db over the reading obtained in (3) above.

(5) Turn the ODD NUMBERED CHANNEL RECEIVER B switch to the ON position. Change the METER SWITCH on the receiver to the B position. The LEVEL METER should read between −20 dbm and −25.5 dbm.

(6) Turn the ODD NUMBERED CHANNEL RECEIVER A switch to the OFF position. The LEVEL METER reading should increase between 0 db and 1.5 db over the reading obtained in (5) above.

(7) Set the COMMON ATTENUATOR on the DIVERSITY ALIGNMENT PANEL to the 20 position, and the ODD NUMBERED CHANNEL RECEIVER A and RECEIVER B switches in the ON position.

(8) Repeat the procedures in (3) through (6) above.

(9) Set the COMMON ATTENUATOR on the DIVERSITY ALIGNMENT PANEL to the 40 position, and the ODD NUMBERED CHANNEL RECEIVER A and RECEIVER B switches in the ON position.

(10) Repeat the procedures (3) through (6) above.

*d. Ratio Squaring Characteristic Test.* This test, described in (1) through (9) below, checks the performance of the expanding circuits of the receiver. The same test setup is used as in *b* and *c* above.

(1) Set the COMMON ATTENUATOR on the DIVERSITY ALIGNMENT PANEL to the 0 position and set the ODD NUMBERED CHANNEL RECEIVER A and B OUTPUT switches to the ON position and the EVEN NUMBERED CHANNEL OUTPUT switches in the OFF position.

(2) Connect the BRIDGING jacks of the LEVEL METER to the RECEIVER B MONITOR jacks and check that the level is −20 dbm.

(3) Unscrew the four captive thumbscrews on the front panel of the receiver and withdraw the chassis, rotating it up into the maintenance position (fig. 43). Remove the bottom cover.

(4) Connect Electronic Multimeter ME-6A/U between terminals 2 and 7 (ground) of terminal board TB7 on agc amplifier AR3. Adjust the RECEIVER A LEVEL ADJ control until the multimeter reads exactly 3.0 volts.

(5) Connect the BRIDGING jacks of the LEVEL METER to the RECEIVER A MONITOR jacks and record the exact level reading.

(6) Set the RECEIVER A LEVEL ADJ control for a LEVEL METER reading exactly 10 db less than that recorded in (5) above. The multimeter should read between .31 and .38 volt.

(7) Reset the RECEIVER A, LEVEL ADJ control for a normal reading of −20 dbm.

(8) Repeat the procedures in (2) through (7) above for RECEIVER B.

(9) Return the RECEIVER A and RECEIVER B DELAY ADJ controls to their original settings. Replace the bottom cover.

(10) Line up the receiver in accordance with paragraph 99 before returning it to service.

## 296. Troubleshooting Chart, Receiver

(figs. 209 and 210)

The following chart is supplied as an aid in locating trouble in a receiver. This chart lists the symptoms which are observed when sectionalizing the Telegraph Terminal AN/FGC–29 for trouble. The chart also lists the probable cause of a symptom and gives the localization and isolation procedures to be used to correct it. After the trouble has been localized to a subassembly or circuit in

RECEIVER A or RECEIVER B of the receiver, trouble isolation tests, or voltage and resistance measurements, should be sufficient to locate the trouble. The trouble isolation tests are described in paragraphs 298 through 300. Delay tuner and receiver filter tests are discussed in paragraphs 301 and 302, respectively. The voltage and resistance measurements are given in tabular form in paragraph 303. If the troubleshooting chart indicates the specific subassembly or circuit in which the trouble is likely to be found, trouble localization or isolation should begin with the test indicated by the paragraph reference in the *correction* column. Otherwise, the trouble localization procedures should begin with the first step given in paragraph 297.

| Symptom | Probable trouble | Correction |
|---|---|---|
| 1. No transmission through RECEIVER A and RECEIVER B. | *a.* Failure of ac power supply. | *a.* Check ac power source. Check power cord and connector. Check for presence of 230 volts ac between terminals 1 and 4 on transformer T3 of plate supply PS1. Check fuses F1 and F2 and indicator lamps I 1 and I 2. |
| | *b.* Failure of B-plus voltage. | *b.* Check for 200 v dc between terminals 1 and 2 on terminal board TB4 of plate supply PS1. If present, check power circuit continuity. If absent, perform trouble isolation tests for plate supply PS1 (par. 300). |
| | *c.* Failure of heater voltage. | *c.* Check for 6.3 v ac between terminals 3 and 5 on terminal board TB4 of plate supply PS1. If present, check heater circuit continuity. If absent, perform trouble isolation tests for plate supply PS1 (par. 300). |
| 2. No transmission through RECEIVER A. | *a.* Defective jack or wiring in RECEIVER A INPUT jack group. | *a.* Check jacks and wiring in INPUT jack group, jacks J1 through J4. |
| | *b.* Defective receiver filter FL1. | *b.* Perform filter tests (par. 302). |
| | *c.* Failure of delay amplifier AR1. | *c.* Perform trouble isolation tests on delay amplifier AR1 (par. 298). |
| | *d.* Failure of agc amplifier AR3. | *d.* Perform trouble isolation tests on agc amplifier AR3 (par. 299). |
| | *e.* Faulty varistors | *e.* Replace varistors CR1 and CR2. |
| 3. No transmission through RECEIVER B. | *a.* Defective jack or wiring in RECEIVER B INPUT jack group. | *a.* Check jacks and wiring in INPUT jack group jacks J7 through J10. |
| | *b.* Defective receiver filter FL2. | *b.* Perform filter tests (par. 302). |
| | *c.* Failure of delay amplifier AR2. | *c.* Perform trouble isolation tests on delay amplifier AR2 (par. 298). |
| | *d.* Failure of agc amplifier AR4. | *d.* Perform trouble isolation tests on agc amplifier AR4 (par. 299). |
| | *e.* Faulty varistors | *e.* Replace varistors CR3 and CR4. |
| 4. Improper tracking between RECEIVER A and RECEIVER B. | *a.* Misaligned receiver | *a.* Check to see that levels at receiver MONITOR jacks are correct. If not, perform alignment procedure (par. 99). |
| | *b.* Faulty agc amplifier in either path. | *b.* Perform trouble isolation tests on agc amplifier AR3 and AR4 (par. 299). |
| | *c.* Faulty agc interconnections. | *c.* Check interconnecting wiring between agc amplifiers. Check varistors CR1 through CR4. Check DIVERSITY switch S5 on associated combiner. |

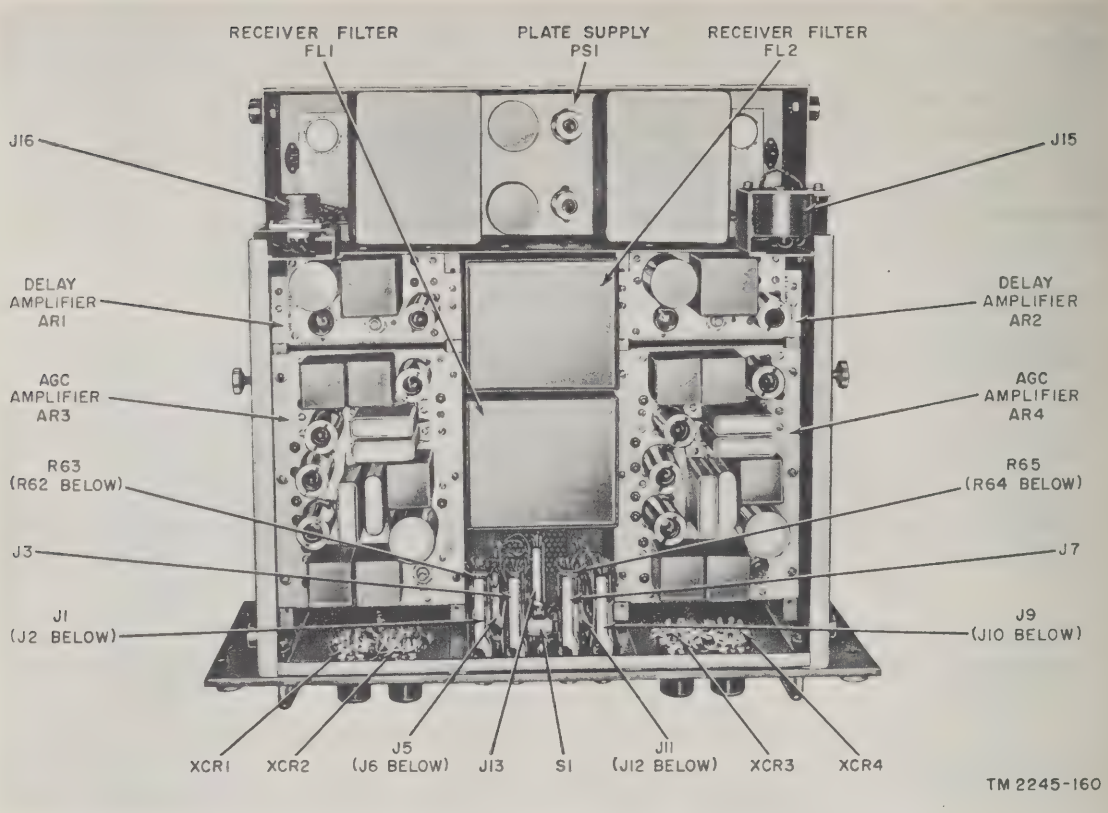



*Figure 209. Receiver, top view.*

## 297. Trouble Localization, Receiver

The general procedure for localizing trouble is described in paragraph 239*c*. To trace trouble in the receiver it is necessary to test RECEIVER A and RECEIVER B. Set up Signal Generator SG–15/PCM as indicated in *a* below. Then measure voltages with Electronic Multimeter ME–6A/U in accordance with *b* below. Trace the test signal on the schematic diagram of the receiver (fig. 255). To check the actual wiring, refer to the wiring diagram of the receiver (fig. 282).

*a. Test Setup.* The test setup is the same as for the operational test (par. 295*a*).

*b. Localization tests, receiver.*

(1) Record the setting of the DELAY ADJ control in delay amplifier AR1.

(2) Read and record the level of the RECEIVER A MONITOR jacks using the BRIDGING jacks of the LEVEL METER in the RECEIVER METER PANEL.

(3) Set the DELAY ADJ control of delay amplifier AR1 to 0.

(4) Set the LEVEL ADJ control of delay amplifier AR1 to the full clockwise position.

(5) Do not disturb the setting of the MON LEVEL ADJ controls in agc amplifier AR3 or AR4 during the tests.

(6) Connect the electronic multimeter between terminal 2 of terminal board TB7 in agc amplifier AR3 and ground. A meter reading between 6.0 and 10.0 volts is normal.

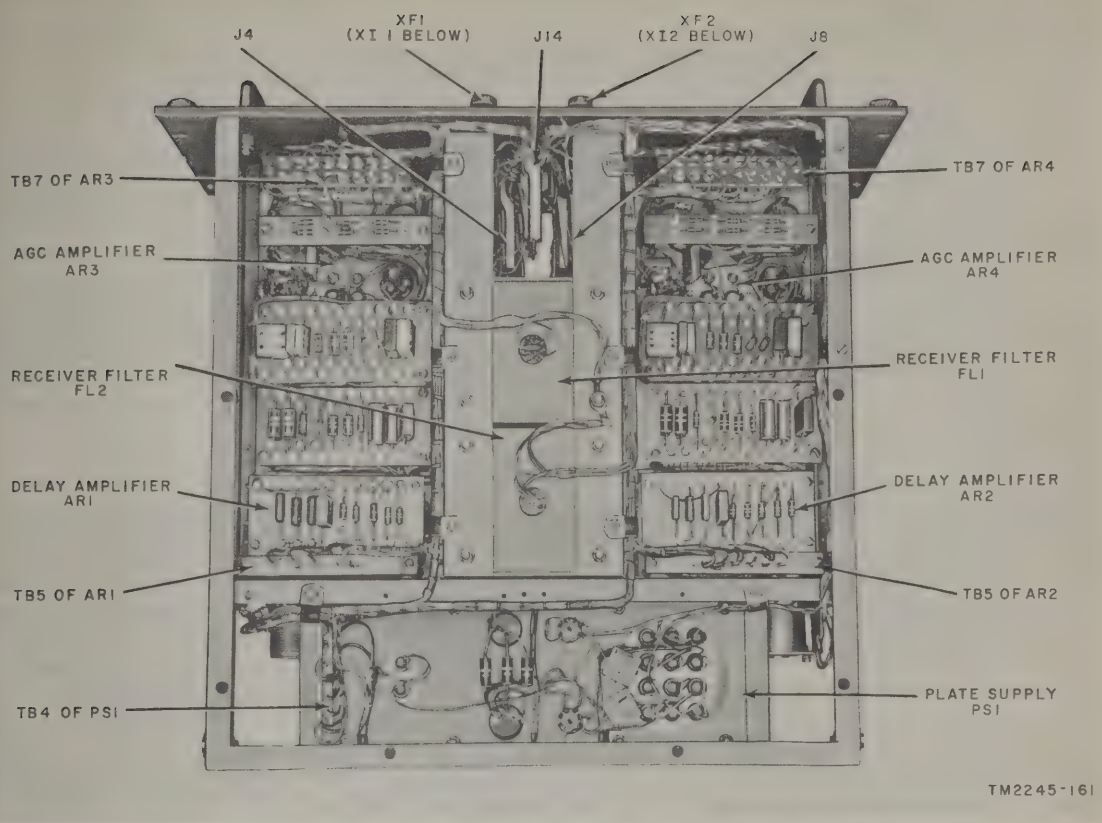



*Figure 210. Receiver, bottom view.*

(7) Set the COMMON ATTENUATOR switch on the DIVERSITY ALIGNMENT PANEL to the 40 position.

(8) The electronic multimeter connected as in (6) above should now read between 10 and 20 percent less than in subparagraph (6) for a properly operating receiver.

(9) If voltage readings in (6) and (8) above are incorrect, try disconnecting connector J16 at rear of receiver and repeat the measurements. If the multimeter readings in either (6) or (8) above are still outside the prescribed limits, proceed with the localization measurements listed in the table below.

(10) Make the above test on RECEIVER B by turning the associated OUTPUT switch on the DIVERSITY ALIGNMENT PANEL to ON and the OUTPUT switch for RECEIVER A to OFF. Repeat the procedures in (1) through (9) for RECEIVER B.

(11) Return the settings of the DELAY ADJ controls to the values recorded in (1) above.

(12) Readjust the LEVEL ADJ controls to obtain the same readings recorded in (2) above.

(13) Line up the receiver in accordance with paragraph 99 before returning it to service.

*Note.* In the following table, reference symbols for RECEIVER B are given in parentheses following those for RECEIVER A.

| Test No. | Electronic Multimeter ME-6A/U probe connections | Reading (volts ac) | | Corrective measures |
|---|---|---|---|---|
| | | Normal | Below* | |
| 1 | Receiver filter FL1 (FL2), terminal 1 and ground. | 0. 31 | ------- | Check wiring between filter FL1 (FL2) and jack J3 (J9). |
| 2 | Terminal board TB5 in delay amplifier AR1 (AR2), terminal 1 and ground. | 1. 4 | ------- | Check receiver filter FL1 (FL2) (par. 302). Check jacks J1 (J7) and J2 (J8). Check wiring between filter and delay amplifier. Perform isolation tests for delay amplifier AR1 (AR2) (par. 298). |
| 3 | Terminal board TB7 in agc amplifier AR3 (AR4), terminal 1 and ground. | 8. 0 | 0. 008 | Perform isolation tests for delay amplifier AR1 (AR2) (par. 298). Check wiring between delay amplifier AR1 (AR2) and agc amplifier AR3 (AR4). |
| 4 | Terminal board TB7 in agc amplifier AR3 (AR4), terminal 2 and ground. | 7. 8 | 5. 5 | Disconnect connector J16. Perform isolation tests for agc amplifier AR3 (AR4) (par. 299). Check varistors CR1 (CR3) and CR2 (CR4). Check wiring between agc amplifier AR3 (AR4) and varistors CR1 (CR3) and CR2 (CR4). |

**Normal* readings obtained with the COMMON ATTENUATOR switch of the DIVERSITY ALIGNMENT PANEL at 0 and *below* readings with the switch at 40.

## 298. Trouble Isolation, Receiver, Delay Amplifier AR1 or AR2

(figs. 211–213)

The general procedure to be followed in isolating trouble is discussed in paragraph 239*d*.

*a. Test Setup.* The test setup for isolating trouble in the delay amplifier, AR1 or AR2, is the same as that used for the operational test of the receiver (par. 295*a*). Usually the trouble isolation tests are made immediately following the localization tests, with the test setup left intact. Measure the voltages listed in *b* below, using Electronic Multimeter ME–6A/U. Trace the test signal through the delay amplifier on the schematic diagram of the receiver (fig. 255). To check the actual wiring refer to the delay amplifier wiring diagram (fig. 284).

*b. Isolation Tests, Delay Amplifier.* Perform the isolation tests given in the table below with the DELAY ADJ control in both the 0 and 10 positions. When the isolation tests are completed, return the DELAY ADJ control to its normal setting.

| Test No. | Electronic Multimeter ME-6A/U probe connections | Normal reading (volts) | | Corrective measures |
|---|---|---|---|---|
| | | Delay 0 | Delay 10 | |
| 1 | Terminal board TB6, terminal 16 and ground (plate of V1A). | 0. 80 | ------- | Check tube V1. Measure dc voltages and resistance at tube socket (par. 303). Check wiring between terminal board TB5 and tube socket XV1. Check resistors R4, R1, and R2 and capacitor C20A. |
| 2 | Terminal board TB6, terminal 1 and ground. | . 80 | ------- | Check resistor R5 and delay tuner (par. 301). |
| 3 | Terminal board TB6, terminal 18 and ground. | 8. 0 | 4. 0 | Check tube V1. Measure dc voltages and resistances at tube socket (par. 303). Check resistor R6, and capacitors C1 and C20B. Check delay tuner (par. 301). Check OUTPUT pin jack J45 for short to ground. |
| 4 | Terminal board TB5, terminal 4 and ground | 8. 0 | 4. 0 | Check capacitor C2. Check wiring between terminal board TB5 and tube socket XV1. |

*Note.* Normal reading in tests 3 and 4 made with the DELAY ADJ control at 0 and 10, consecutively.

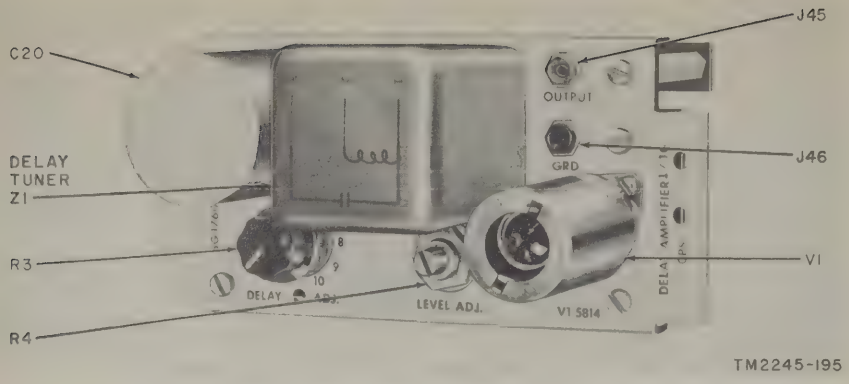



*Figure 211. Delay amplifier, top view.*

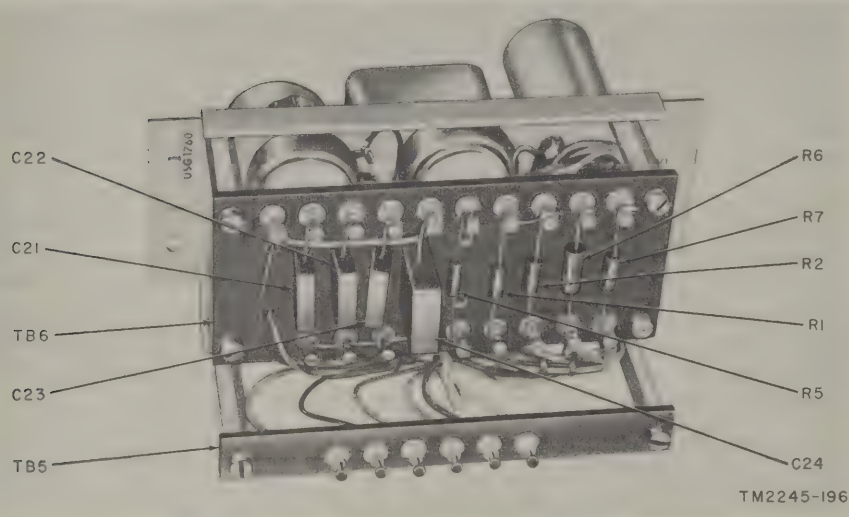



*Figure 212. Delay amplifier, bottom view.*

## 299. Trouble Isolation, Receiver, agc Amplifier AR3 or AR4

(figs. 214 through 217)

The general procedure to be followed in isolating trouble is discussed in paragraph 239*d*. Usually the trouble isolation tests are made immediately following the localization tests with the test setup left intact. To isolate trouble in the agc amplifier set up the equipment as indicated in *a* below and make the voltage measurements listed in *b* below, using Electronic Multimeter ME–6A/U and Multimeter TS–352/U as indicated. Trace the test signal through the agc amplifier on the receiver schematic diagram (fig. 255). To check the actual wiring, refer to the agc wiring diagram (fig. 282).

*a. Test Setup.* The test setup for isolating trouble in the agc amplifier is the same as that used for the operational test of the receiver (par. 295*a*) and (1) through (4) below.

(1) Measure the level at the MONITOR jack of the agc amplifier under test with the BRIDGING jacks of the LEVEL METER on the RECEIVER METER PANEL.

(2) Set the COMMON ATTENUATOR switch in the DIVERSITY ALIGNMENT PANEL to the 40 position.

(3) Remove the varistors CR1 or CR3 and CR2 or CR4 associated with the agc amplifier under test from the sockets on the front panel of the receiver.

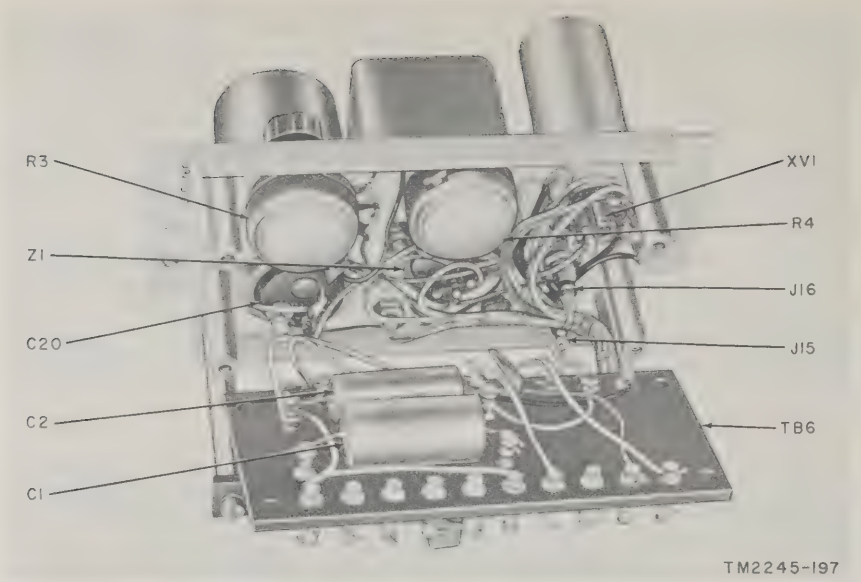



*Figure 213. Delay amplifier, bottom view, terminal board TB6 removed and rotated.*

(4) Set the signal level, as measured with the electronic multimeter connected between terminal 1 of terminal board TB7 and ground, to .014 volt. To do this, adjust the LEVEL ADJ control on the delay amplifier associated with the agc amplifier under test.

*b. Isolation Test, agc amplifier.* Perform the isolation tests given in the table below. Upon completion of the tests, replace the varistors and reset the LEVEL ADJ control to obtain the same reading recorded in *a*(1) above (COMMON ATTENUATOR on the DIVERSITY ALIGNMENT PANEL set to 0).

| Test No. | Test meter | Meter connections | Normal reading (volts) | Corrective measures |
|---|---|---|---|---|
| 1 | Electronic Multimeter ME–6A/U. | Terminal board TB7, terminal 1 and ground. | 0. 014 ac | Check transformer T1 and resistor R10. Check wiring from terminal board TB7 to transformer T1. |
| 2 | Electronic Multimeter ME–6A/U. | Tube socket XV5, terminal 2 and ground. | . 0008 ac | Check transformer T1. Check to see that all terminals on terminal board TB1 are free of ground. Check resistors R8, R9, R11 through R14. Check transformer T2. Check tube V5. Measure dc voltages and resistances at tube socket XV5 (par. 303). Check capacitor C4 and resistor R19. |
| 3 | Electronic Multimeter ME–6A/U. | Tube socket XV5, terminal 7 and ground. | . 027 ac | Check tube V5. Measure dc voltages and resistance at tube socket XV5 (par. 303). Check capacitors C5A and C6. Check feedback circuit-resistor R35 and R20 and capacitors C14 and C16. |
| 4 | Electronic Multimeter ME–6A/U. | Terminal board TB2, terminal 2 (terminal 1 of XV6) and ground. | 9. 0 ac | Check tubes V5 and V6. Measure dc voltages and resistance at tube sockets XV5 and XV6 (par. 303). Check capacitors C5B, C9, and C10. Check resistor R32 and diode CR5. |

| Test No. | Test meter | Meter connections | Normal reading (volts) | | Corrective measures |
|---|---|---|---|---|---|
| 5 | Electronic Multimeter ME–6A/U. | Terminal board TB2, terminal 7 (terminal 3 of XV7) and ground. | 6. 0 | ac___ | Check tube V7. Check dc voltages and resistances at tube socket XV7 (par. 303). Check capacitors C15 and C18 and transformer T4. |
| 6 | Electronic Multimeter ME–6A/U. | Terminal board TB2, terminal 10 and 12 (terminal 3 and 5 of T4) and ground. | 12 | ac___ | Check transformer T4, diodes CR8 and CR9, and resistor R42. |
| 7 | Multimeter TS–352/U. | Terminal board TB7, terminal 12 and ground. | +11 | dc___ | Check diodes CR6 and CR7 and resistors R38 through R41, and capacitor C13. Check same parts in other agc amplifier. |
| 8 | Multimeter TS–352/U. | Terminal board TB7, terminal 11 and ground. | +13 | dc___ | Check +200 plate supply voltage. Check capacitor C3B and resistors R15 through R18. Check these resistors in both agc amplifiers. |
| 9 | Multimeter TS–352/U. | Terminal board TB7, terminal 10 and ground. | +13 | dc___ | Check tube V6. Measure dc voltages and resistances at tube socket XV6 (par. 303). Check resistors R37, and R38 and capacitor C11 and C12. Check tube V6 and perform measurments at socket XV6 in other agc amplifier. |
| 10 | Electronic Multimeter ME–6A/U. | Terminal board TB3, terminal 16 (terminal 1 of transformer T5) and ground. | 3. 5 | ac___ | Chieck tube V7. Measure dc voltages and resistance at tube socket XV7 (par. 303). Check transformer T5 and capacitor C29. |
| 11 | Electronic Multimeter ME–6A/U. | Terminal board TB3, terminal 9 and 11 (terminals 3 and 5 of transformer T5). | 6. 2 | ac___ | Check transformer T5 (par. 303*a*). Check diodes CR12 and CR13 and resistors R51 and R54. |
| 12 | Multimeter TS–352/U. | Terminal board TB3, terminal 28 (terminal 4 of transformer T5) and ground. | +3. 3 | dc___ | Check transformer T5 (par. 303*a*). Check diodes CR12 and CR13. Check resistors R54 and R51. |
| 13 | Multimeter TS–352/U. | Terminal board TB3, terminal 30 (terminal 7 of transformer T5) and ground. | ±13. 60 | dc___ | Check transformers T5 and T6 (par. 303*a*). Check diodes CR10 and CR11, resistors R52 and R53 and capacitors C19 and C25. |
| 14 | Electronic Multimeter ME–6A/U. | Terminal board TB3, terminals 8 and 26 (terminals 1 and 4 of transformer T6) and ground. | . 0062 | ac___ | Check transformers T5 and T6 (par. 303*a*). Check diodes CR10 and CR11 and resistor R52. |
| 15 | Electronic Multimeter ME–6A/U. | Terminal board TB3, terminal 40 (terminal 1 of tube socket XV8) and ground. | . 45 | ac___ | Check tube V8. Check dc voltages and resistance measurements at tube socket XV8 (par. 303). Check transformer T6, resistor R55 and feedback resistors R56 and R59 and capacitor C27. |
| 16 | Electronic Multimeter ME–6A/U. | Terminal board TB7, terminal 2 and ground. | 6. 0 | ac___ | Check tube V8. Check dc voltages and resistance measurements at tube socket XV8 (par. 303). Check capacitors C26 and C28 and resistor R61. |

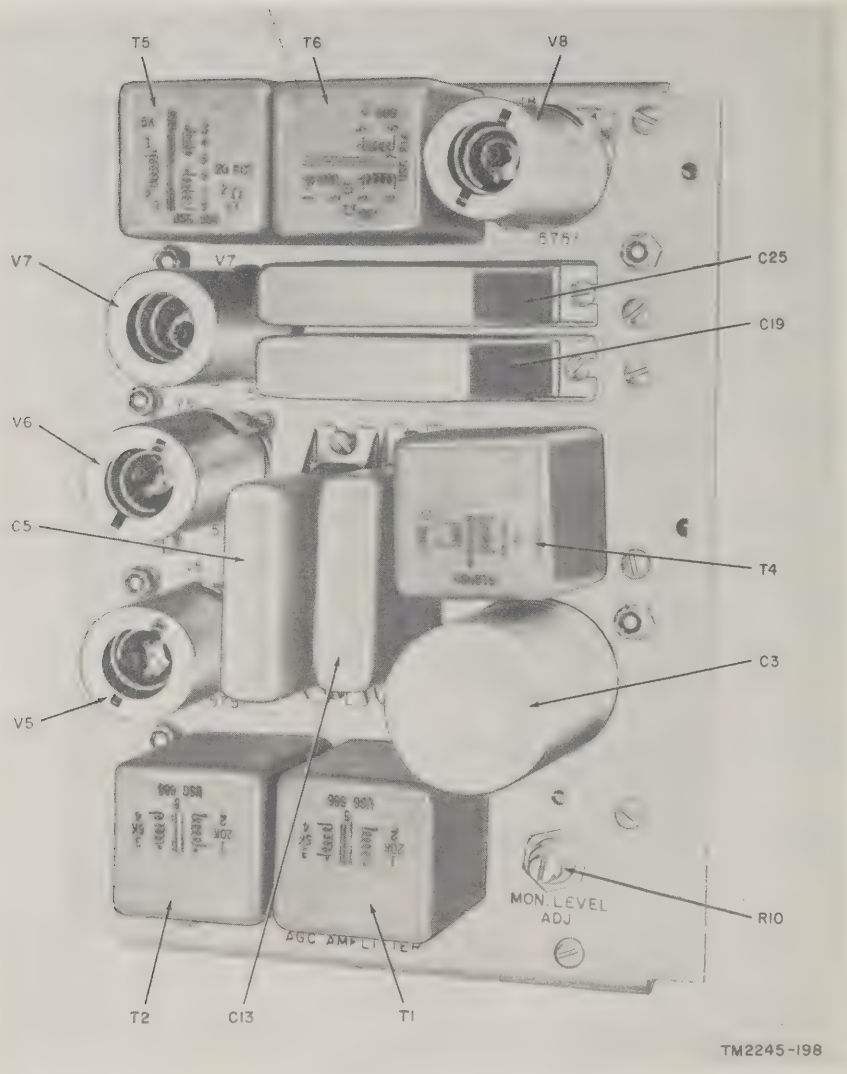



*Figure 214. Agc amplifier, top view.*

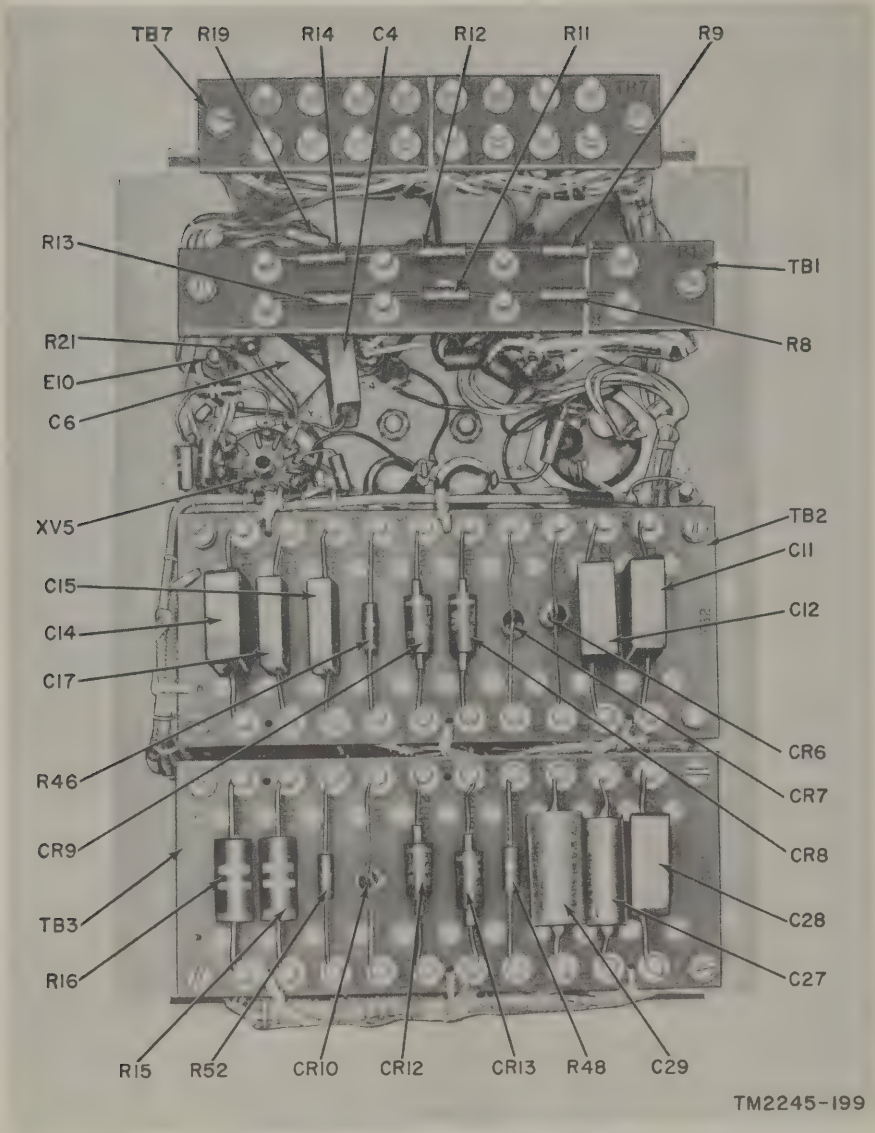



*Figure 215. Agc amplifier, bottom view.*

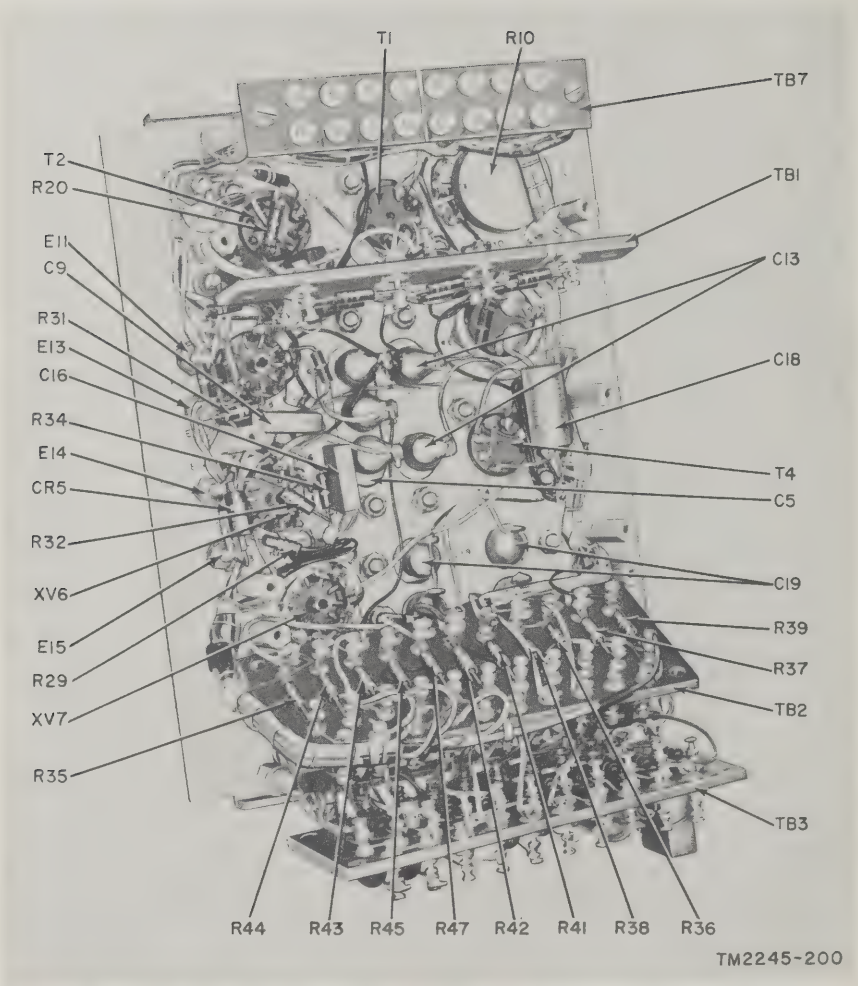



*Figure 216. Agc amplifier, bottom view, terminal boards TB1, TB2, and TB3 removed and rotated.*

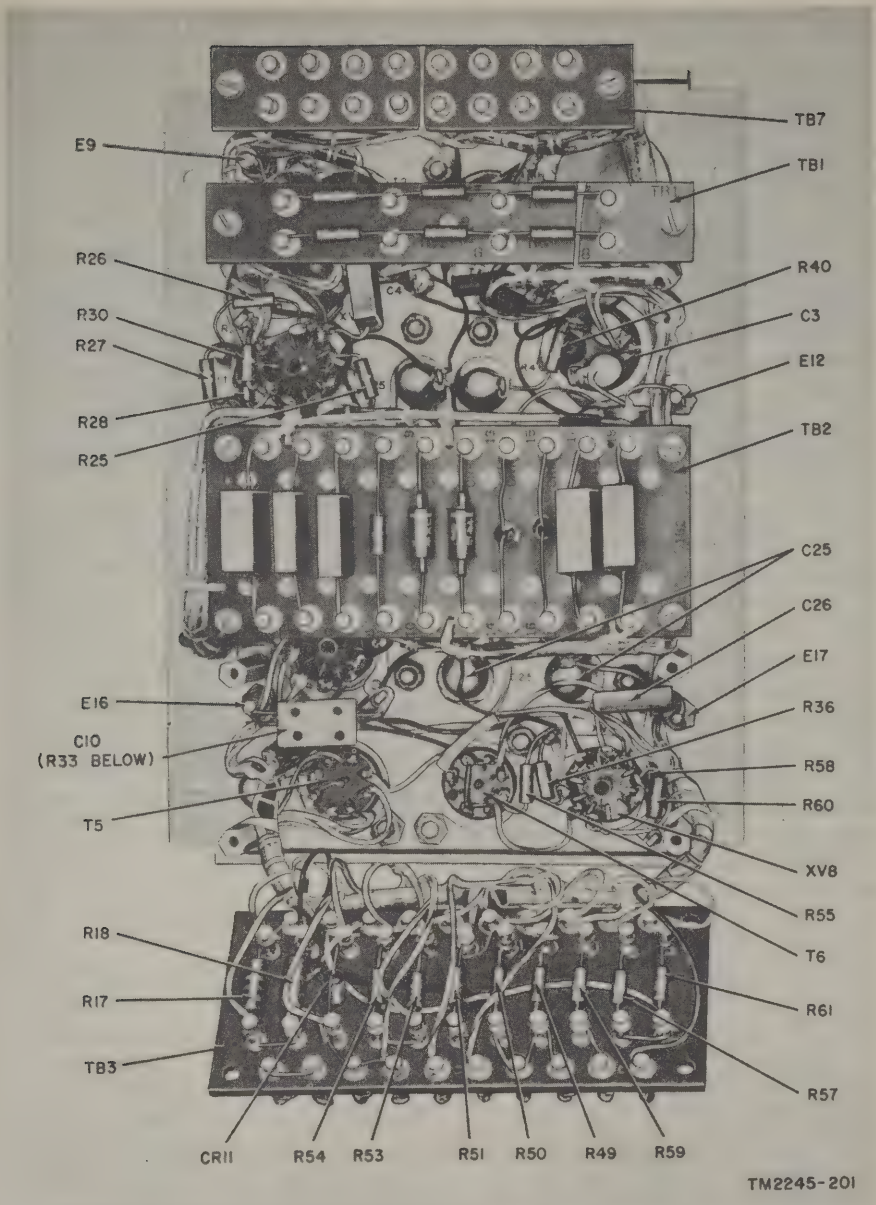



*Figure 217. Agc amplifier, bottom view, terminal board TB3 removed and rotated.*

## 300. Trouble Isolation, Receiver, Plate Supply

Plate supply PS1 in the receiver is identical with plate supply PS1 in the SUBGROUP MODULATOR. Refer to paragraph 273 for the trouble isolation procedure for this equipment.

## 301. Delay Tuner Tests, Receiver

(fig. 218)

The delay tuners are nonrepairable sealed units that must be replaced if found to be defective. Test the delay tuners by measuring their frequency

of minimum response when disconnected from their associated circuits. Also measure the resistance between the terminals of the delay tuner.

*a. Test Equipment Required.* The test equipment required consists of Signal Generator SG–15/PCM, Frequency Meter FR–67/U or Frequency Counter AN/USM–26, and Electronic Multimeter ME–6A/U. The signal generator provides the test signal for measuring the response of the delay tuner under test, and the frequency meter provides accurate measurement of the test frequency. The electronic multimeter measures the voltage response across the delay tuner.

*b. Test Connections.* Connect the equipment as shown in figure 218. The delay tuners require a 600-ohm resistor and a 620-uuf ±2 percent mica capacitor for the test setup. Proceed as follows:

(1) Connect a 600-ohm resistor across the signal generator output terminals.
(2) Connect the input terminals of the frequency meter across the signal generator output terminals.
(3) Connect the input terminals of the electronic multimeter across the signal generator output terminals.
(4) Connect a 620-uuf ±2 percent mica capacitor between terminals 1 and 3 of the delay tuner.
(5) Connect terminal 3 of the delay tuner to the ground terminal of the signal generator.

*c. Measurements.*

(1) Adjust the output frequency of the signal generator to the frequency specified in the table in *d* below, as indicated on the frequency meter.
(2) Adjust the output level of the signal generator to −20 db as indicated on the electronic multimeter.
(3) Connect the second terminal of the signal generator to terminal 2 of the delay tuner.
(4) Vary the output frequency of the signal generator to obtain a minimum reading on the electronic multimeter. The frequency at this point as measured on the frequency meter must be within ±5 cps of the frequency specified in the table in *d* below.

*d. Test Frequencies, Delay Tuners.* The frequencies for which minimum response should be obtained for the delay tuners are listed below.

| Delay tuner channel | Frequency (cps) |
|---|---|
| 1/16 | 1, 785 |
| 2/15 | 2, 975 |
| 3/14 | 1, 955 |
| 4/13 | 2, 805 |
| 5/12 | 2, 125 |
| 6/11 | 2, 635 |
| 7/10 | 2, 295 |
| 8/9 | 2, 465 |

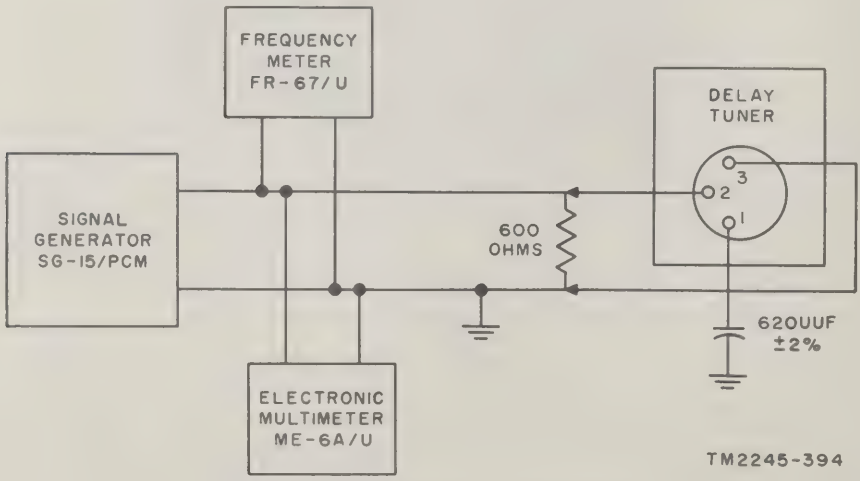



*Figure 218. Delay tuner, test arrangement.*

## 302. Filter Tests, Receiver
(fig. 180)

The receiver filters are nonreparable sealed units that must be replaced if found to be defective. These filters are tested by measuring the transmission characteristics of each filter at specified frequencies with the filter removed from the receiver circuit. Measure also the resistances between the various filter terminals (par. 303*a*).

*a. Test Equipment Required.* The test equipment required consists of Signal Generator SG–15/PCM, Frequency Meter FR–67/U or Frequency Counter AN/USM–26, and Electronic Multimeter ME–6A/U. The signal generator provides input signals for the filter under test and the frequency meter provides an accurate measurement of the test frequency. The electronic multimeter measures the input and the output voltages of the filter under test.

*b. Test Connections.* Connect the equipment as shown in figure 180. The receiver filters require a 600-ohm resistor to match the impedance at terminals 1 and 2 and a 100,000-ohm resistor to match the impedance at terminals 3 and 4. Proceed as follows:

(1) Connect one output terminal of the signal generator to terminal 1 of a receiver filter under test through a 600-ohm, ½-watt resistor.
(2) Connect the second output terminal of the signal generator to terminal 2 of the filter.
(3) Connect terminal 2 of the filter to ground.
(4) Connect the input leads of the frequency meter to the output terminals of the signal generator.
(5) Connect a 100,000-ohm, ½-watt resistor between terminals 3 and 4 of the filter.

*c. Measurements.* Each receiver filter is tested at its center frequency (*e* below) and at frequencies of 45 cps and 125 cps above and below the center frequency. Proceed as follows:

(1) Connect the electronic multimeter to the output terminals of the signal generator.
(2) Adjust the output frequency of the signal generator to the frequency specified for test 1 in *d* below. Each receiver filter has a different center frequency, as listed in *e* below.
(3) Adjust the signal generator output voltage to voltage E1 specified in *d* below.
(4) Disconnect the multimeter from the signal generator and connect it between terminals 3 and 4 of the filter.
(5) The measured voltage (E2 in *d* below) should be within the indicated limits.
(6) Repeat the procedure given in (1) through (5) above for each frequency listed in the table in *d* below for the particular receiver filter under test.

*d. Normal Readings, Receiver Filters.* The receiver filters are normal if voltage readings E2 in tests 1 through 5 in the chart below fall within the indicated limits.

| Test | Test frequency (cps) | E1 (volts) | E2 (volts) |
|---|---|---|---|
| 1 | Center frequency minus 125 cps. | 0. 775 | 0. 0078 max |
| 2 | Center frequency minus 45 cps. | . 775 | 1. 84 min |
| 3 | Center frequency | . 775 | 2. 45 min |
| 4 | Center frequency plus 45 cps. | . 775 | 1. 84 min |
| 5 | Center frequency plus 125 cps. | . 775 | . 0078 max |

*Note.* Accurate measurements in tests 1 and 5 require that harmonics in the signal generator output be at least 60 db below the test signal level, or that a low-pass filter be used to filter the test signal. An alternative is to measure voltage E2 with a wave analyzer, such as Sound Analyzer TS–615/U, in place of Electronic Multimeter ME–6A/U.

*e. Test Frequencies, Receiver Filters.* The center frequency of each receiver filter is listed below.

| Receiver filter designation | Center frequency (cps) |
|---|---|
| 1/16 | 1, 785 |
| 3/14 | 1, 955 |
| 5/12 | 2, 125 |
| 7/10 | 2, 295 |
| 8/9 | 2, 465 |
| 6/11 | 2, 635 |
| 4/13 | 2, 805 |
| 2/15 | 2, 975 |

## 303. Additional Troubleshooting Information, Receiver

*a. Typical Resistance Readings.* The resistances of transformers and filters are measured with all connections removed from their terminals. The resistance at the terminals of tube sockets are measured with all connections intact and all conditions normal except that the power is disconnected from the component. Typical resistance

measurements for subassemblies of the receiver are given in (1) through (4) below.

(1) *Delay amplifier AR1 or AR2.*

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Tube socket: | | | |
| XV1 | 3 | Ground | 1, 200 |
| | 7 | Ground | 1, 200 |
| | 8 | Ground | 2, 200 |

(2) *Delay tuner Z1.*

| Channel | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| 1/16 | 1 | 2 | 46 |
| 2/15 | 1 | 2 | 18 |
| 3/14 | 1 | 2 | 46 |
| 4/13 | 1 | 2 | 18 |
| 5/12 | 1 | 2 | 31 |
| 6/11 | 1 | 2 | 26 |
| 7/10 | 1 | 2 | 31 |
| 8/9 | 1 | 2 | 26 |

(3) *Agc amplifier AR3 or AR4.*

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Transformer: | | | |
| T1, T2 | 1 | 2 | 79 |
| | 3 | 4 | 54 |
| T4 | 1 | 2 | 67 |
| | 3 | 4 | 220 |
| | 3 | 5 | 500 |
| T5 | 1 | 2 | 100 |
| | 3 | 5 | 280 |
| | 6 | 7 | 1. 6 |
| | 7 | 8 | 1. 6 |
| T6 | 1 | 2 | 7. 4 |
| | 3 | 4 | 7. 8 |
| | 5 | 6 | 140 |
| Tube socket: | | | |
| XV5 | 2 | Ground | 100, 000 |
| | 3 | Ground | 1, 200 |
| | 7 | Ground | 1 meg |
| | 8 | Ground | 1, 200 |
| XV6 | 3 | Ground | 2, 200 |
| XV7 | 2 | Ground | 2. 2 meg |
| | 3 | Ground | 9, 700 |
| | 7 | Ground | 2. 2 meg |
| | 8 | Ground | 8, 400 |
| XV8 | 2 | Ground | 140 |
| | 3 | Ground | 1, 200 |
| | 7 | Ground | 1 meg |
| | 8 | Ground | 1, 200 |

(4) *Receiver filters FL1 and FL2.*

| Channel | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| 1/16 | 1 | 3 | Infinite |
| | 1 | 2 | Infinite |
| | 3 | 4 | 36 |
| | 2 | 4 | 0 |
| 2/15 | 1 | 3 | Infinite |
| | 1 | 2 | Infinite |
| | 3 | 4 | 14 |
| | 2 | 4 | 0 |
| 3/14 | 1 | 3 | Infinite |
| | 1 | 2 | Infinite |
| | 3 | 4 | 33 |
| | 2 | 4 | 0 |
| 4/13 | 1 | 3 | Infinite |
| | 1 | 2 | Infinite |
| | 3 | 4 | 14 |
| | 2 | 4 | 0 |
| 5/12 | 1 | 3 | Infinite |
| | 1 | 2 | Infinite |
| | 3 | 4 | 24 |
| | 2 | 4 | 0 |
| 6/11 | 1 | 3 | Infinite |
| | 1 | 2 | Infinite |
| | 3 | 4 | 16 |
| | 2 | 4 | 0 |
| 7/10 | 1 | 3 | Infinite |
| | 1 | 2 | Infinite |
| | 3 | 4 | 23 |
| | 2 | 4 | 0 |
| 8/9 | 1 | 3 | Infinite |
| | 1 | 2 | Infinite |
| | 3 | 4 | 21 |
| | 2 | 4 | 0 |

*b. Typical Voltage Readings.* Voltages are measured with the equipment connected to its regular power supply, with tubes in place and all conditions normal. Typical voltage measurements for the delay amplifier and agc amplifier are given in (1) and (2) below.

(1) *Delay amplifier AR1 or AR2.*

| Item | Measure from terminal | Measure to terminal | Voltage (volts) |
|---|---|---|---|
| Tube socket: | | | |
| XV1 | 1 | Ground | +150 dc |
| | 3 | Ground | +4. 7 dc |
| | 4, 5 | 9 | 6. 3 ac |
| | 6 | Ground | +87 dc |
| | 7 | Ground | +4. 7 dc |
| | 8 | Ground | +6. 6 dc |

(2) *Agc amplifier AR3 or AR4.*

| Item | Measure from terminal | Measure to terminal | Voltage (volts) |
|---|---|---|---|
| Tube sockets: | | | |
| XV5 | 1 | Ground | +100 dc |
| | 3 | Ground | +.9 dc |
| | 4, 5 | 9 | 6.3 ac |
| | 6 | Ground | +110 dc |
| | 8 | Ground | +.9 dc |
| XV6 | 1 | Ground | +60 dc |
| | 3 | Ground | +.7 dc |
| | 4, 5 | 9 | 6.3 ac |
| | 6 | Ground | +200 dc |
| | 7 | Ground | +11 dc |
| | 8 | Ground | +13 dc |
| Tube sockets: | | | |
| XV7 | 1 | Ground | +200 dc |
| | 3 | Ground | +38 dc |
| | 4, 5 | 9 | 6.3 ac |
| | 6 | Ground | +200 dc |
| | 8 | Ground | +32 dc |
| XV8 | 1 | Ground | +100 dc |
| | 3 | Ground | +.9 dc |
| | 4, 5 | 9 | 6.3 ac |
| | 6 | Ground | +110 dc |
| | 8 | Ground | +.9 dc |

## Section XIV. TROUBLESHOOTING, COMBINER

### 304. Operational Test, COMBINER CHANNELS 1 and 2 Through COMBINER CHANNELS 15 and 16

The general procedure to be followed in performing an operational test is described in paragraph 239*b*. To determine if a combiner is functioning properly, check the performance of both combiner channels separately (2-channel diversity) and combined (4-channel diversity). Before starting the test, note the settings of the following controls (figs. 55 and 56) and restore them to these settings after the test is completed.

| Control | Quantity |
|---|---|
| DIVERSITY switch | 1 |
| IDLE-NORMAL switch | 2 |
| LOOP CURRENT switch | 2 |
| DISCRIMINATOR switch | 2 |

*a. Test Setup.* See that the external loops of the combiner are closed to ground. The combiner remains in place connected to its normal power and signal cable as installed. The associated receivers and corresponding transmitter, known to be correctly lined up, are required to test the combiner. The transmitter is required as a source of input signals and is connected through the DIVERSITY ALIGNMENT PANEL to the associated receivers as follows:

(1) Set the DIVERSITY switch on the transmitter to the 4 CHANNEL loop 1 only position.

(2) Set both LOOP CURRENT SELECTOR switches of the transmitter to 60MA.

(3) Set both LOOP TERMINATION switches of the transmitter to NEG.

(4) Connect the odd-numbered channel EQUIP jack of the transmitter to the DOTTER OUTPUT jack on the TRANSMITTER METER PANEL.

(5) Connect the odd-numbered CHANNEL OUTPUT jacks on the transmitter to the ODD NO. CHAN. INPUT jacks on the DIVERSITY ALIGNMENT PANEL.

(6) Connect the even-numbered CHANNEL OUTPUT jacks on the transmitter to the EVEN NO. CHAN. INPUT jacks on the DIVERSITY ALIGNMENT PANEL.

(7) Set the COMMON ATTENUATOR switch on the DIVERSITY ALIGNMENT PANEL to 0.

(8) Connect the RECEIVER A EQUIP jacks on the odd channel receiver to the RECEIVER A ODD NUMBERED CHANNEL OUPTUT jacks on the DIVERSITY ALIGNMENT PANEL and the RECEIVER B EQUIP jacks of the same receiver to the RECEIVER B ODD NUMBERED CHANNEL OUTPUT jacks. Similarly, connect the RECEIVER A and RECEIVER B EQUIP jacks of the even-channel receiver to their corresponding EVEN NUMBERED CHANNEL OUTPUT jacks on the DIVERSITY ALIGNMENT PANEL.

(9) Set the ODD NUMBERED CHANNEL RECEIVER A OUTPUT switch to the ON position to energize the A path of the odd-numbered combiner channel. Set the remaining output switches to OFF.

(10) Set the MARK-SPACE-DOT switch of the DOTTER to the MARK position.

*b. Two-Channel Diversity.* Set the DIVERSITY switch of the combiner in the 2 CHANNEL, LOOPS 1 & 2 position. See that the DIVERSITY switch can be operated from the remote control station. Set both combiner IDLE-NORMAL switches in the NORMAL position. (Be sure each LOOP IDLE INDICATOR lights when the corresponding switch is thrown momentarily to the IDLE position). Set both LOOP CURRENT switches to the 60 MA position and both DISCRIMINATOR switches to the NORMAL position.

(1) Connect the odd-numbered LOOP MONITOR jack on the combiner to the LOOP CURRENT METER INPUT jack on the RECEIVER METER PANEL. Adjust the associated LOOP CURRENT ADJUST control of the combiner for a reading of exactly 60 ma.

(2) Operate the MARK-SPACE-DOT switch on the TRANSMITTER METER PANEL to the DOT position. The LOOP CURRENT METER should read approximately 30 ma, and when the BIAS switch is depressed, should read 60 ma. If necessary, adjust the associated BIAS ADJUST control for a reading of 60 ma.

(3) Set the MARK-SPACE-DOT switch of the DOTTER to the MARK position. Set the ODD NUMBERED CHANNEL RECEIVER A OUTPUT switch on the DIVERSITY ALIGNMENT PANEL to the OFF position and the ODD NUMBERED CHANNEL RECEIVER B OUTPUT switch to the ON position and repeat the instructions in (1), (2), and (3) above for the B path of the odd-numbered combiner channel.

(4) Connect the even-numbered loop MONITOR jack on the combiner to the LOOP CURRENT METER INPUT jack on the RECEIVER METER PANEL. Set the EVEN NUMBERED CHANNEL RECEIVER A OUTPUT switch on the DIVERSITY ALIGNMENT PANEL to the ON position and turn the ODD NUMBERED CHANNEL RECEIVER B OUTPUT switch to the OFF position. Repeat the instructions in (1), (2), and (3) above for the A path and those in (4) above for the B path of the even-numbered combiner channel.

*c. Four-Channel Diversity.* Set the DIVERSITY switch on the combiner to the 4-CHANNEL, LOOP 1 ONLY position. The even-numbered LOOP IDLE INDICATOR lights. Set both LOOP CURRENT switches in the 20 MA position. Connect the LOOP CURRENT METER INPUT jack on the RECEIVER METER PANEL to the odd-numbered channel MONITOR jack on the combiner. See that the MARK-SPACE-DOT switch of the DOTTER is in the MARK position.

(1) Turn the ODD NUMBERED CHANNEL RECEIVER A OUTPUT switch on the DIVERSITY ALIGNMENT PANEL to the ON position and turn the other three OUTPUT switches to the OFF position. Adjust the odd-numbered channel LOOP CURRENT ADJUST control until the LOOP CURRENT METER reads 20 ma.

(2) Turn the ODD NUMBERED CHANNEL RECEIVER A OUTPUT switch on the DIVERSITY ALIGNMENT PANEL to the OFF position and turn the ODD NUMBERED CHANNEL RECEIVER B OUTPUT switch to the ON position. The LOOP CURRENT METER should again read 20 ma. Repeat this procedure for the EVEN NUMBERED CHANNEL RECEIVER A and RECEIVER B OUTPUT switches. The LOOP CURRENT METER should continue to read 20 ma in each case.

*d. Line-up Check.* Check the line-up of the combiner in accordance with the procedure given in paragraph 100 before returning it to service.

## 305. Combiner, Troubleshooting Chart

The following chart is supplied as an aid in locating trouble in the combiner. This chart lists the symptoms that can be observed when sectionalizing trouble in Telegraph Terminal AN/FGC–29. The chart also lists the probable cause of a symptom and gives the localization and isolation

procedures to be used to correct it. After trouble has been localized to a subassembly or circuit in the combiner, trouble isolation tests or voltage and resistance measurements should be sufficient to locate the trouble. If the troubleshooting chart indicates the specific subassembly or circuit in which the trouble is likely to be found, trouble localization or isolation should begin with the test indicated by the paragraph reference in the *correction* column. Otherwise, the trouble localization procedures should begin with the first step given in paragraph 306.

| Symptom | Probable trouble | Correction |
|---|---|---|
| 1. No telegraph signal in either odd or even loop. | *a.* Failure of ac power supply. | *a.* Check ac power source. Check power cord and connectors. Check for presence of 230 v ac between terminals 7 and 8 (ground) of terminal board TB7 in transformer-reactor assembly Z3. Check fuse F1 and indicator lamp I 1. |
| | *b.* Failure of loop battery voltage. | *b.* Check for presence of −130 v dc between terminal 17 of terminal board TB4 in adders AR1 and AR2 and ground. |
| | *c.* Defective DIVERSITY switch S5. | *c.* Check contacts of DIVERSITY switch S5. |
| 2. No telegraph signal in the odd loop. | *a.* Failure of B-plus voltage. | *a.* Check for presence of 200 v dc between terminal 15 of terminal board TB4 of adder AR1 and ground. If present, check B-plus circuit continuity. If absent, check interdrawer connection to associated receiver. Check plate supply PS1 (par. 300) in associated receiver. |
| | *b.* Failure of loop battery voltage. | *b.* Check for presence of −130 v dc between terminal 17 of terminal board TB4 of adder AR1 and ground. |
| | *c.* Failure of heater voltage. | *c.* Check for presence of 6.3 v ac between terminals 15 and 16 and terminals 17 and 18 of terminal board TB6 of transformer-reactor assembly Z3. If present, check heater circuit continuity. If absent, check for 230 v ac at terminals 1 and 4 of transformer T1. If present, check transformer T1 (par. 309). |
| | *d.* Defective wiring between connector J10 and adder AR1. | *d.* Check wiring between terminals R and S of connector J10 and terminals 13 and 14, respectively, of terminal board TB4 of adder AR1. |
| | *e.* Failure of adder AR1. | *e.* Perform trouble isolation on adder AR1 (par. 307). |
| | *f.* Failure of discriminator Z1. | *f.* Check discriminator Z1 (par. 309). |
| | *g.* Defective inductors in transformer-reactor assembly Z3. | *g.* Check inductors L1 through L4 in transformer-reactor assembly Z3 (par. 309). |
| | *h.* Defective IDLE-NORMAL switch S3. | *h.* Check wiring between adder AR1 and IDLE-NORMAL switch S3. Check switch S3. |
| | *i.* Defective DIVERSITY switch S5. | *i.* Check DIVERSITY switch S5. Check wiring between adder AR1 and switch S5. |
| | *j.* Defective jack or wiring in odd channel OUTPUT LOOP jack group. | *j.* Check jacks and wiring to jacks J3, J4, and J5 and check connections to terminal 9 of terminal board TB1 in adder AR1. Check connections to terminal A of connector J10. |
| 3. No telegraph signal in even loop. | *a.* Failure of B-plus voltage. | *a.* Check for presence of 200 v dc between terminal 15 of TB4 of adder AR2 and ground. If present, check B-plus circuit continuity. If absent, check interdrawer connections to associated receiver. Check plate supply PS1 (par. 300) in associated receiver. |
| | *b.* Failure of loop battery voltage. | *b.* Check for presence of −130 v dc between terminal 17 of terminal board TB4 of adder AR2 and ground. |

| Symptom | Probable trouble | Correction |
|---|---|---|
| 3. No telegraph signal in even loop. | *c.* Failure of heater voltage. | *c.* Check for presence of 6.3 v ac between terminals 1 and 2 and 3 and 4 of terminal board TB7 of transformer-reactor assembly Z3. If present, check heater circuit continuity. If absent, check for 230 V ac at terminals 1 and 4 of transformer T2. If present, check transformer T2 (par. 309). |
| | *d.* Defective wiring between connector J10 and adder AR2. | *d.* Check wiring between terminals T and U of connector J10 and terminals 13 and 14, respectively, of terminal board TB4 of adder AR2. |
| | *e.* Failure of adder AR2. | *e.* Perform trouble isolation on adder AR2 (par. 307). |
| | *f.* Failure of discriminator Z2. | *f.* Check discriminator Z2 (par. 309). |
| | *g.* Defective inductors in transformer-reactor assembly Z3. | *g.* Check inductors L5 through L8 in transformer reactor assembly Z3 (par. 309). |
| | *h.* Defective IDLE-NORMAL switch S4. | *h.* Check wiring between adder AR2 and IDLE-NORMAL switch S4. Check switch S4. |
| | *i.* Defective DIVERSITY switch S5. | *i.* Check DIVERSITY switch S5. Check wiring between adder AR2 and switch S5. |
| | *j.* Defective jack or wiring in even-channel OUTPUT LOOP jack group. | *j.* Check jacks and wiring to jacks J6, J7, and J8 and check connections to terminal 9 of terminal board TB1 in adder AR2. Check connection to terminal B of connector J10. |
| 4. Excessive bias in either loop. | *a.* Incorrect bias adjustment. | *a.* Align combiner (par. 100). |
| | *b.* Discriminator out of alignment. | *b.* Perform test and tuning procedure for discriminator (par. 308). |

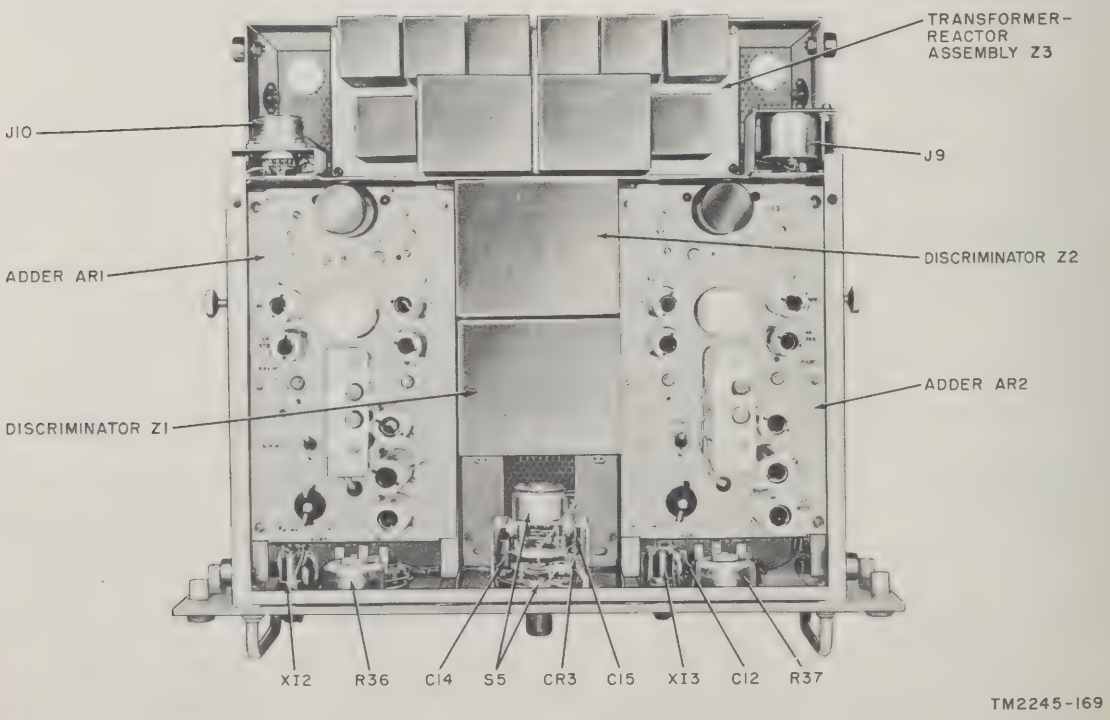



*Figure 219. Combiner, top view.*

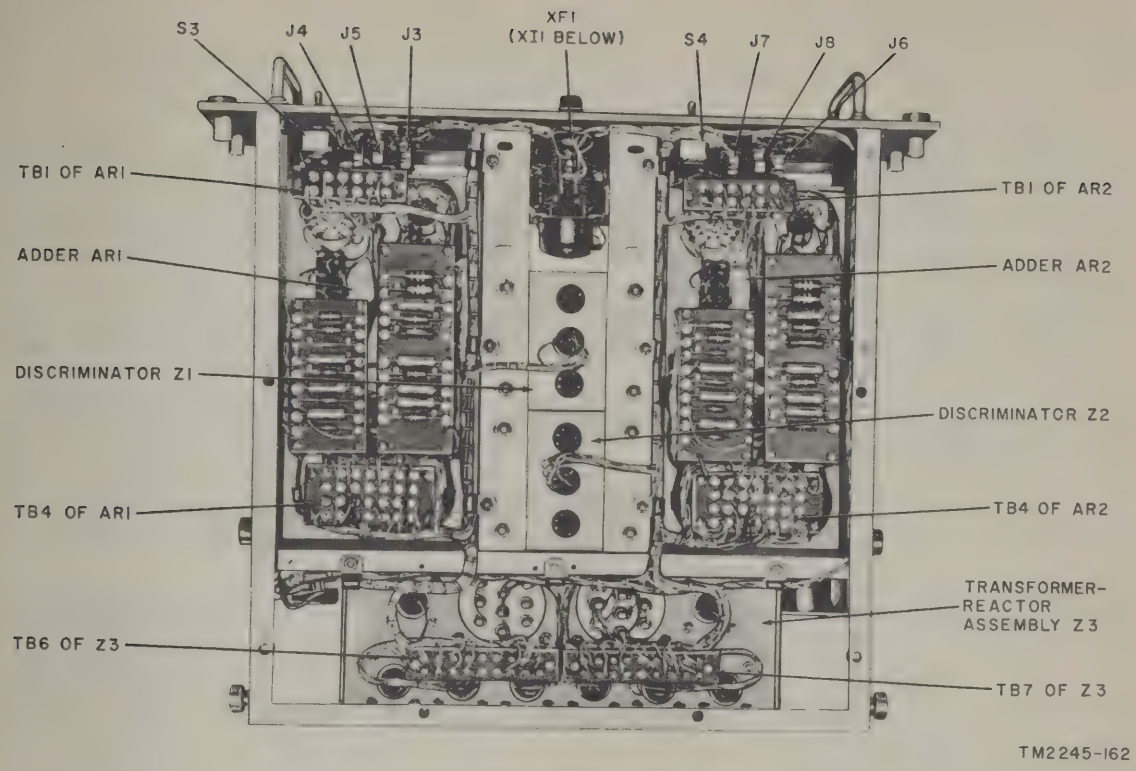



*Figure 220. Combiner, bottom view.*

## 306. Trouble Localization, Combiner

(figs. 219 and 220)

The general procedure for localizing trouble is described in paragraph 239*c*. To trace trouble in the combiner, test the even or the odd channel, or both, including the A and B paths in each channel. To localize trouble in either the odd or even channel, set up the equipment as indicated in *a* below. Measure voltages with Electronic Multimeter ME–6A/U and Multimeter TS–352/U in accordance with *b* or *c* below. Trace the signal path under test on the combiner schematic diagram (fig. 256). To check the actual wiring, refer to the combiner wiring diagram (fig. 285).

*a. Test Setup, Combiner.* The test setup for the trouble localization tests is the same as for the operational test (par. 304*a*(1) through (10)), except set the switches below as follows:

(1) Set the DIVERSITY switch to the 2-CHANNEL, loop 1 only position.

(2) Set both IDLE-NORMAL switches to the NORMAL position.

(3) Set both LOOP CURRENT switches to the 60 MA position and adjust the loop current for each combiner channel to 60 ma with the associated LOOP CURRENT ADJUST control.

*b. Localization Tests, Combiner.* Perform the tests indicated in the tables below to localize trouble in the combiner. When making these tests, energize only one combiner path (A or B path, odd- or even-numbered combiner channel) appropriate to the location of the probe connections of the test meter. Use the OUTPUT switches on the DIVERSITY ALIGNMENT PANEL. Use the MARK-SPACE-DOT switch of the DOTTER to obtain marking or spacing frequency signals.

*Note.* In the following tables, reference symbols for the even-numbered channel are given in the *Corrective measures* column in parentheses following those for the odd-numbered channel.

(1) *Localization tests, combiner, A path.*

| Step | Meter | Probe Connections | Normal reading (volts) | | Corrective measures |
|---|---|---|---|---|---|
| | | | Mark | Space | |
| 1 | Electronic, Multimeter, ME–6A/U. | Terminal board TB4 of adder, AR1 or AR2, terminal 13 and ground. | 5.5 ac | 5.5 v ac | Check wiring between terminal R (T) of connector J10 and terminal 13 of terminal board TB4 of adder AR1 (AR2). |
| 2 | Electronic Multimeter ME–6A/U. | Terminal board TB4 of adder AR1 or AR2, terminal 1 and ground. | 75 ac | 75 ac | Perform isolation test on adder AR1 (AR2) (par. 307). |
| 3 | Electronic Multimeter ME–6A/U. | Terminal board TB4 of adder AR1 or AR2, terminal 4 and 3. | 60 ac | 85 ac | Check wiring between adder AR1 (AR2) and discriminator Z1 (Z2). Test discriminator Z1 (Z2) (par. 308). |
| 4 | Electronic Multimeter ME–6A/U. | Terminal board TB4 of adder AR1 or AR2, terminal 2 and 3. | 85 ac | 60 ac | Check wiring between adder AR1 (AR2) and discriminator Z1 (Z2) test discriminator Z1 (Z2) (par. 308). |
| 5 | Multimeter TS–352/U. | Terminal board TB4 of adder AR1 or AR2, terminal 7(+) and 5(−). | −24 dc | +24 dc | Perform isolation test on adder AR1 (AR2) (par. 307). |
| 6 | Multimeter TS–352/U. | Terminal board TB4 of adder AR1 or AR2, terminal 8(+) and 6(−). | −24 dc | +24 dc | Check inductors L2 and L3 (L6 and L7) of transformer-reactor assembly Z3 par. 309). Check wiring between adder AR1 (AR2) and transformer-reactor assembly Z3. |
| 7 | LOOP CURRENT METER of RECEIVER METER PANEL. | EQUIP jack of odd or even channel (DIVERSITY switch in 2-CHANNEL, LOOPS 1 and 2 position). | 60 ma dc | 0 ma dc | Perform isolation test for adder AR1 (AR2) (par. 307). Check wiring between adder and switch S5 and switch S3 (S4). Check switches S5 and S3 (S4). Check wiring between adder and resistor R36 (R37). Check wiring between adder AR1 (AR2) and jacks J3 (J6), J4 (J7), and J5 (J8). |
| 8 | LOOP CURRENT METER of RECEIVER METER PANEL. | EQUIP jack of odd channel (DIVERSITY switch in 4-CHANNEL, LOOP 1 only position). | 60 ma dc | 0 ma dc | Perform isolation tests for adder AR1 (AR2) (par. 307). Check wiring between adder and switch S5 and switch S3 (S4). Check wiring between adder and resistor R36 (R37). Check wiring between adder AR1 (AR2) and jacks J3 (J6), J4 (J7), and J5 (J8). |

(2) *Localization tests, combiner, B path.*

| Step | Meter | Probe connections | Normal reading (volts) | | Corrective measures |
|---|---|---|---|---|---|
| | | | Mark | Space | |
| 1 | Electronic Multimeter ME–6A/U. | Terminal board TB4 of adder AR1 or AR2, terminal 14 and ground. | 5.5 ac | 5.5 ac | Check wiring between terminal S (U) of connector J10 and terminal 14 on adder AR1 (AR2). |
| 2 | Electronic Multimeter ME–6A/U. | Terminal board TB4 of adder AR1 or AR2, terminal 25 and ground. | 75 ac | 75 ac | Perform isolation tests on adder AR1 (AR2) (par. 307). |
| 3 | Electronic Multimeter ME–6A/U. | Terminal board TB4 of adder AR1 or AR2, terminal 27 and 28. | 60 ac | 85 ac | Check wiring between adder AR1 (AR2) and discriminator Z1 (Z2). Test discriminator Z1 (Z2) (par. 308). |
| 4 | Electronic Multimeter ME–6A/U. | Terminal board TB4 of adder AR1 or AR2, terminals 26 and 27. | 85 ac | 60 ac | Check wiring between adder AR1 (AR2) and discriminator Z1 (Z2). Test discriminator Z1 (Z2) (par. 308). |
| 5 | Multimeter TS–352/U. | Terminal board TB4 of adder AR1 or AR2, terminal 23 (+) and 21 (−). | −24 dc | +24 dc | Perform isolation test on adder AR1 (AR2) (par. 307). |
| 6 | Multimeter TS–352/U. | Terminal board TB4 of adder AR1 or AR2, terminals 24 (+) and 22 (−). | −24 v dc | +24 v dc | Check inductors L1 and L4 (L5 and L8) of transformer-reactor assembly Z3 (par. 309). Check wiring between adder AR1 (AR2) and transformer-reactor assembly Z3. |
| 7 | LOOP CURRENT METER of RECEIVER METER PANEL. | EQUIP jack of odd or even channel (DIVERSITY switch in 2-CHANNEL, loops 1 and 2 position). | 60 ma dc | 0 ma dc | Perform isolation test for adder AR1 or AR2 (par. 307). Check wiring between adder and switch S5 and switch S3 (S4). Check switches S5 and S3 (S4). Check wiring between adder and resistor R36 (R37). Check wiring between adder AR1 (AR2) and jacks J3 (J6), J4 (J7), and J5 (J8). |
| 8 | LOOP CURRENT METER of RECEIVER METER PANEL. | EQUIP jack of odd channel (DIVERSITY switch in 4-CHANNEL, loops 1 only position). | 60 ma dc | 0 ma dc | Perform isolation test for adder AR1 (AR2) (par. 307). Check wiring between adder and switch S5 and switch S3 (S4). Check switches S5 and S3 (S4). Check wiring between adder and resistor R36 (R37). Check wiring between adder AR1 (AR2) and jacks J3 (J6), J3 (J7), and J5 (J8). |

## 307. Trouble Isolation, Combiner, Adder AR1 or AR2

(figs. 221–223)

The general procedure to be followed in isolating trouble is discussed in paragraph 239*d*.

*a. Test Setup.* The test setup for isolating trouble in adder AR1 or AR2 is the same as that used for localizing trouble in the combiner (par. 306). Usually, the trouble isolation tests are made immediately following the localization tests, with the test setup left intact.

*b. Isolation Tests, Adder, A Path or B Path.* To isolate trouble in adder AR1 or AR2, make the measurements described in the table below. When making these tests, energize only one combiner path (A or B path, odd- or even-numbered channel) appropriate to the adder being tested. Refer to the combiner schematic diagram (fig. 256). To check the actual wiring, refer to the adder wiring diagram (fig. 287).

*Note.* In the following chart, when reference symbols for the A and B paths of the adder differ, the symbol for the B path is given in parentheses following the A path symbol.

| Step | Meter | Probe Connections | Normal reading (volts) | | Corrective measures |
|---|---|---|---|---|---|
| | | | Mark | Space | |
| 1 | Electronic Multimeter ME–6A/U. | Terminal board TB4, terminal 13 (14) and ground. | 5.5 ac | 5.5 ac | Check resistor R11 (R5) and tube V3 (V1). |
| 2 | Electronic Multimeter ME–6A/U. | Terminal board TB4, terminal 1 (25) and ground. | 75 ac | 75 ac | Check tube V3 (V1). Measure dc voltages and resistances at tube socket XV3 (XV1) (par. 309). Check resistor R4 (R12) and capacitor C1B (C1A). Check associated discriminator Z1 or Z2 (par. 308). |
| 3 | Multimeter TS–352/U. | Terminal board TB4, terminal 7 (23) and 5 (21). | −24 dc | +24 dc | Check tube V4 (V2). Check resistors R9 and R10 (R17 and R18) and capacitors C2 and C3 (C5 and C6). Check resistors R8 and R19 (R16 and R13). |
| 4 | Multimeter TS–352/U. | Discriminator OUTPUT jacks J1(+) and J2(−). | −23 dc | +23 dc | Check switch S2. Check resistors R7 and R15 and capacitors C4 and C7. If necessary, adjust LEVEL ADJUST A or B for correct voltage readings. |
| 5 | Multimeter TS–352/U. | Terminal board TB4, terminal 9 and ground. | −200 dc | −200 dc | Check diodes CR1 and CR2 and capacitor C13. Check resistors R23, R24, and R38. Check switches S3 (S4) and S5 in combiner. |
| 6 | Multimeter TS–352/U. | Terminal board TB3, terminal 5 (terminal 3 of tube socket XV5) and ground. | −200 dc | −200 dc | Check tube V5. Measure dc voltages and resistances at tube socket XV5 (par. 309). Check capacitor C10. Check switches S3 (S4) and S5 in combiner. |
| 7 | Multimeter TS–352/U. | Terminal board TB3, terminal 26 (terminal 1 of tube socket XV5) and ground. | −130 dc | −170 dc | Check tube V5. Measure dc voltages and resistances at tube socket XV5 (par. 309). |
| 8 | Multimeter TS–352/U. | Terminal board TB3, (terminal 8 of tube socket XV5) and ground. | −130 dc | −155 dc | Check tubes V5, V6, and V7. Measure dc voltages and resistances at tube sockets XV5, XV6, and XV7 (par. 309). |
| 9 | LOOP CURRENT METER. | EQUIP jack J3 or J6 of channel associated with adder under test. | 60 ma dc or 20 ma dc | 0 ma dc | Check tubes V6 and V7. Measure dc voltages and resistances at tube sockets XV6 and XV7 (par. 309). Check switch S1. |

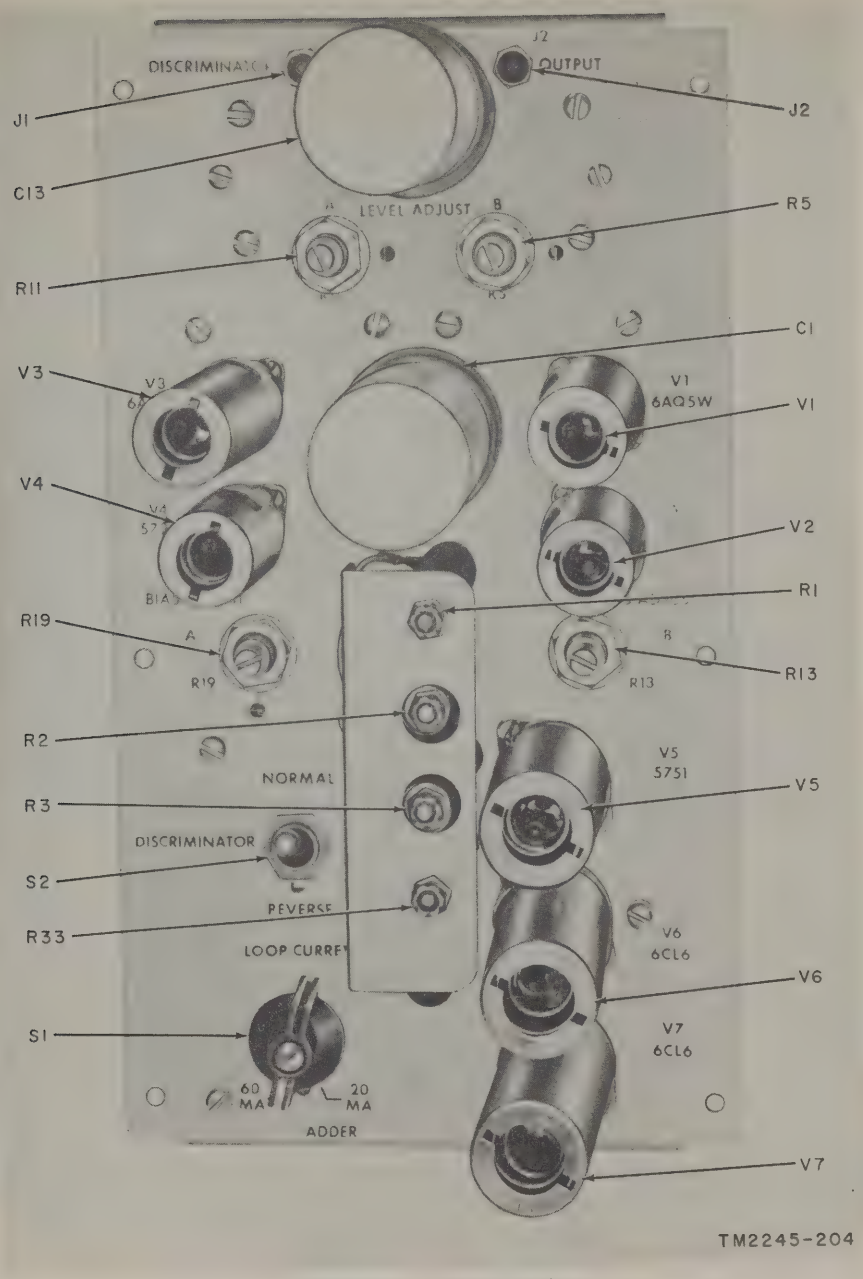



*Figure 221. Adder, top view.*



395139 O—56——25

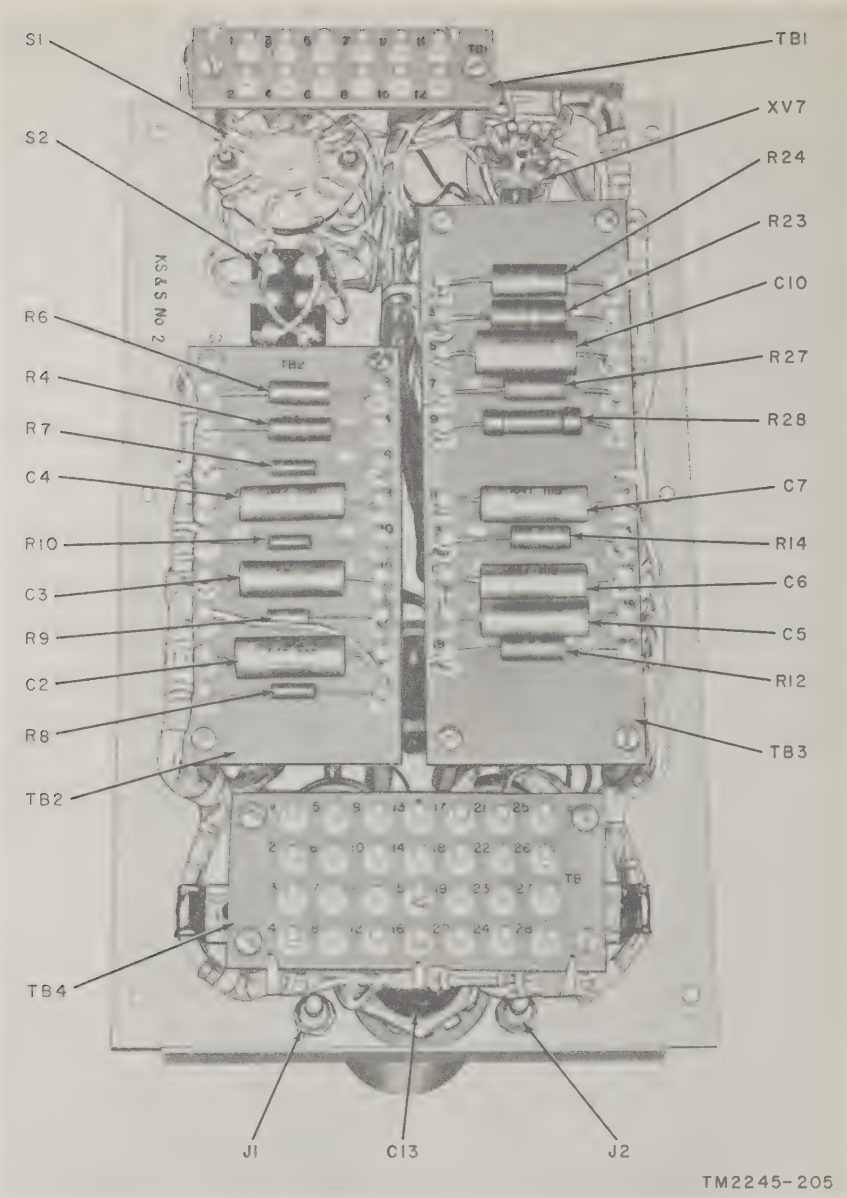



*Figure 222. Adder, bottom view.*

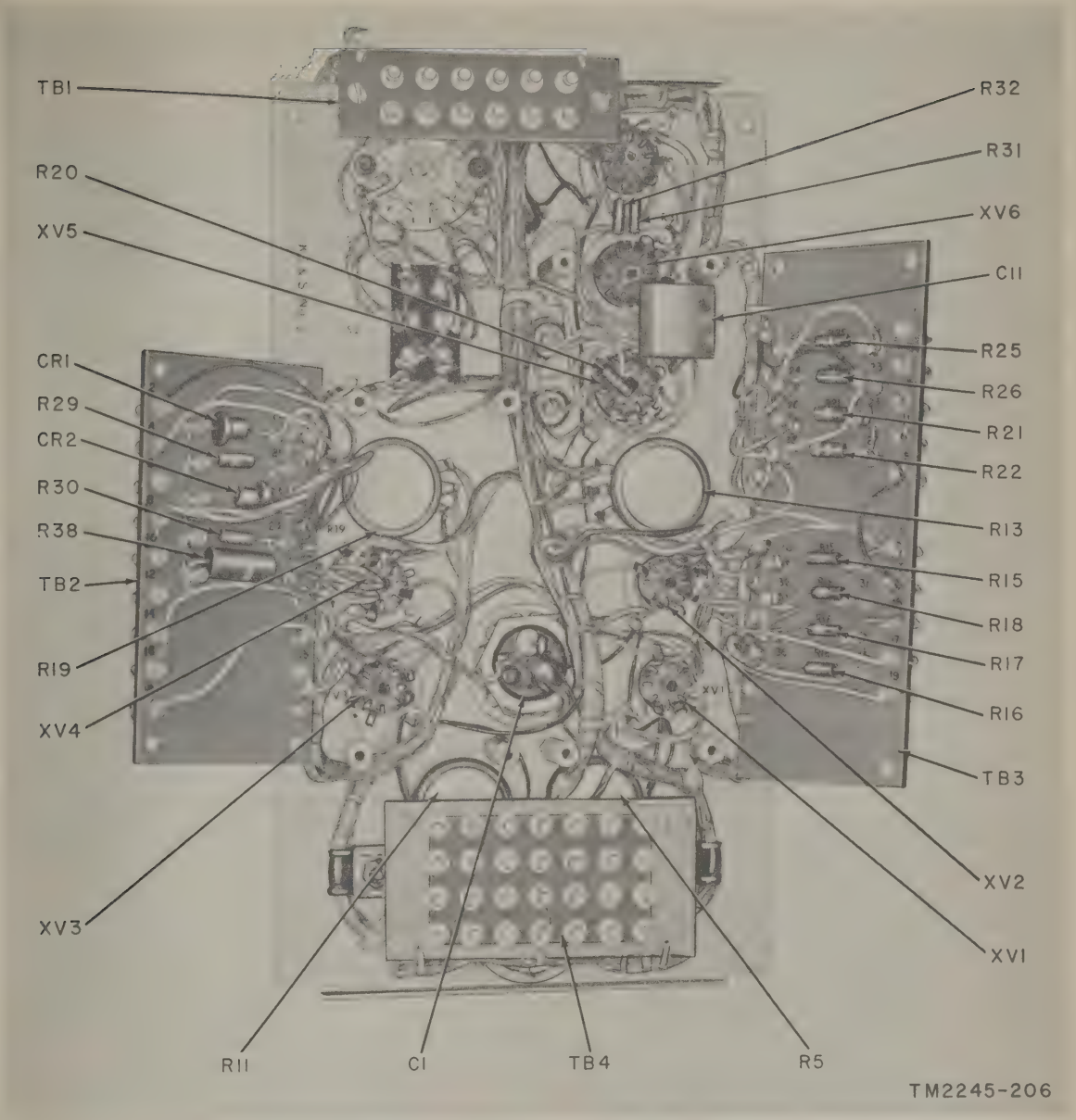



*Figure 223. Adder, bottom view, terminal boards TB2 and TB3 removed and rotated.*

## 308. Discriminator Tests and Adjustments, Combiner

(fig. 224)

The discriminators are nonrepairable sealed units that must be replaced if found to be defective. Retune discriminators that cannot be lined up in accordance with paragraph 100 or are otherwise found to be defective. Replace discriminators that cannot be properly tuned. The discriminators are tuned in place; the associated circuits of the combiner form a test setup for the discriminators. Measurement of the resistance of a discriminator should be made with the leads disconnected from the unit.

*a. Test Equipment Required.* The test equipment required consists of Signal Generator SG-

15/PCM, Frequency Meter FR–67/U or Frequency Counter AN/USM–26, Electronic Multimeter ME–6A/U, and Multimeter TS–352/U.

*b. Connections.* The two discriminators in each combiner are tuned in their normal positions in the combiner drawer. Figure 224 shows the external test connections. Proceed as follows:

(1) Insert open twin plugs into the LINE jacks of RECEIVER A and RECEIVER B of the receiver associated with the particular discriminator under test.

(2) Set the BIAS ADJUST control associated with the particular A or B path of the discriminator under test to the center of its travel and the corresponding LEVEL ADJUST control to the extreme clockwise position (maximum gain).

(3) Set the remaining LEVEL ADJUST controls of the combiner to the extreme counterclockwise position (zero gain).

(4) Set the DIVERSITY switch of the combiner to the 2-CHANNEL, loops 1 and 2 position.

(5) Connect the oscillator to the combiner for the particular discriminator to be tested and tuned as indicated by the following table.

| Discriminator under test | Connect oscillator to terminals |
|---|---|
| Discriminator Z1, A path. | Terminal board TB4 of adder AR1, terminals 13 and 11 (ground). |
| Discriminator Z1, B path. | Terminal board TB4 of adder AR1, terminal 14 and 11 (ground). |
| Discriminator Z2, A path. | Terminal board TB4 of adder AR2, terminal 13 and 11 (ground). |
| Discriminator Z2, B path. | Terminal board TB4 of adder AR2, terminal 14 and 11 (ground). |

(6) Connect the input leads of the frequency meter and the electronic multimeter to the output terminals of the signal generator.

(7) Connect a temporary short-circuiting strap between terminals 2 and 3 (for the A path) or terminals 6 and 7 (for the B path) on the discriminator under test.

(8) Remove all strapping from TRIMMER A (for the A path) or TRIMMER B (for the B path) of the discriminator under test.

(9) Connect the multimeter (50-volt dc range) to the DISCRIMINATOR OUTPUT pin jacks.

*c. Tuning.*

(1) Adjust the oscillator to the frequency and level indicated below for the particular discriminator being tuned.

| Discriminator designation | Oscillator frequency (cps) | Oscillator level (volts) |
|---|---|---|
| 1/16 | 1, 700 | 3. 5 |
| 3/14 | 1, 850 | 3. 5 |
| 5/12 | 2, 015 | 3. 5 |
| 7/10 | 2, 200 | 3. 5 |
| 8/9 | 2, 350 | 3. 5 |
| 6/11 | 2, 525 | 3. 5 |
| 4/13 | 2, 700 | 3. 5 |
| 2/15 | 2, 860 | 3. 5 |

(2) Connect strapping between terminal 9 and terminals 1 through 4 (singly or in combination as required) of TRIMMER A for the A path or TRIMMER B for the B path of the discriminator to obtain the maximum reading on the multimeter.

*Note.* Set the DISCRIMINATOR switch in the position that gives an up-scale reading on the multimeter.

(3) Adjust the oscillator to the frequency and level indicated below for the particular discriminator being tuned.

| Discriminator designation | Oscillator frequency (cps) | Oscillator level (volts) |
|---|---|---|
| 1/16 | 1, 785 | 3. 5 |
| 3/14 | 1, 955 | 3. 5 |
| 5/12 | 2, 125 | 3. 5 |
| 7/10 | 2, 295 | 3. 5 |
| 8/9 | 2, 465 | 3. 5 |
| 6/11 | 2, 635 | 3. 5 |
| 4/13 | 2, 805 | 3. 5 |
| 2/15 | 2, 975 | 3. 5 |

(4) Remove the temporary strapping that was installed as instructed in *b*(7) above.

(5) Connect strapping between terminal 9 and terminals 5 through 8 (singly or in combination as required) of TRIMMER A for the A path or TRIMMER B for the B path of the discriminator for a reading of zero volts ±2 volts.

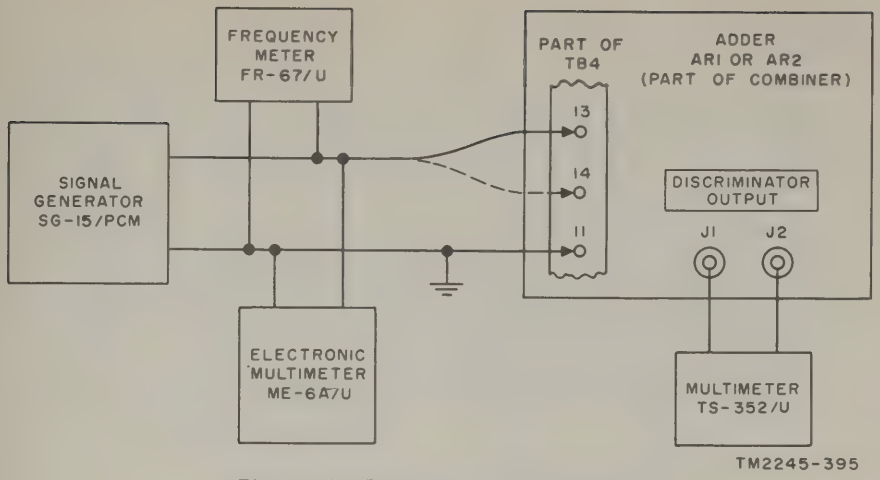



*Figure 224. Discriminator, test arrangement.*

## 309. Additional Troubleshooting Information, Combiner

*a. Typical Resistance Readings.* The resistances of transformers are measured with all connections removed from their terminals. The resistances at the terminals of the tube sockets are measured with all connections intact and all conditions normal except that the power is disconnected from the component. Typical resistance measurements for combiner subassemblies are given in the tables in (1) through (4) below.

(1) *Adders AR1 and AR2.*

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Tube sockets: | | | |
| XV1, XV3 | 2 | Ground | 270 |
| XV2, XV4 | 1 | 5 | 150, 000 |
| XV5 | 1, 7 | Ground | 470, 000 |
| | 6 | Ground | 3, 900 |

(2) *Discriminators Z1 and Z2.*

| Channel | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| 1/16, 3/14, 5/12 | 1 | 9 | 190 |
| | 5 | 9 | 190 |
| | 2 | 4 | 310 |
| | 6 | 8 | 310 |
| 6/11, 7/10, 8/9 | 1 | 9 | 130 |
| | 5 | 9 | 130 |
| | 2 | 4 | 210 |
| | 6 | 8 | 210 |
| 2/15, 4/13 | 1 | 9 | 84 |
| | 5 | 9 | 84 |
| | 2 | 4 | 140 |
| | 6 | 8 | 140 |

(3) *Transformer-reactor assembly Z3.*

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Inductors L1 through L8 | 1 | 2 | 2, 100 |
| Transformers T1 and T2 | 1 | 2 | 34 |
| | 3 | 4 | 38 |
| | 5 | 7 | .24 |
| | 8 | 10 | .28 |

(4) *S5 rotary-type solenoid.*

| Item | Measure | Resistance (ohms) |
|---|---|---|
| Solenoid S5 | Between leads of solenoid winding. | 190 |

*b. Typical Voltage Readings.* Voltages are measured with the equipment connected to its regular power supply with tubes in place and all condi-

tions normal. Typical voltage measurements are given in the table below.

| Item | Measurement from terminal | Measurement to terminal | Voltage (volts) |
|---|---|---|---|
| Tube sockets: | | | |
| XV1, XV3 | 3 | 4 | 6.3 ac |
| | 5 | Ground | +190 dc |
| | 6 | Ground | +160 dc |
| | 2 | Ground | +7.0 dc |
| XV2, XV4 | 3 | 4 | +6.3 ac |
| XV5 | 1, 7 | Ground | −130 dc [a] |
| | | | −175 dc [b] |
| | 3 | Ground | −200 dc |
| | 4, 5 | 9 | 6.3 ac |
| | 6 | Ground | −12 dc [a] |
| | | | 0 dc [b] |
| | 8 | Ground | −130 dc [a] |
| | | | −155 dc [b] |
| Tube sockets: | | | |
| XV6, XV7 | 1, 7 | Ground | −130 dc |
| | 3, 8 | Ground | −65 dc [a] [c] |
| | | | −22 dc [b] [c] |
| | | | −110 dc [a] [d] |
| | | | −95 dc [b] [d] |
| | 4 | 5 | 6.3 ac |
| | 2, 9 | Ground | −130 dc [a] |
| | | | −155 dc [b] |

[a] Indicates marking frequency signal.
[b] Indicates spacing frequency signal.
[c] Indicates loop arranged for 60 ma.
[d] Indicates loop arranged for 20 ma.

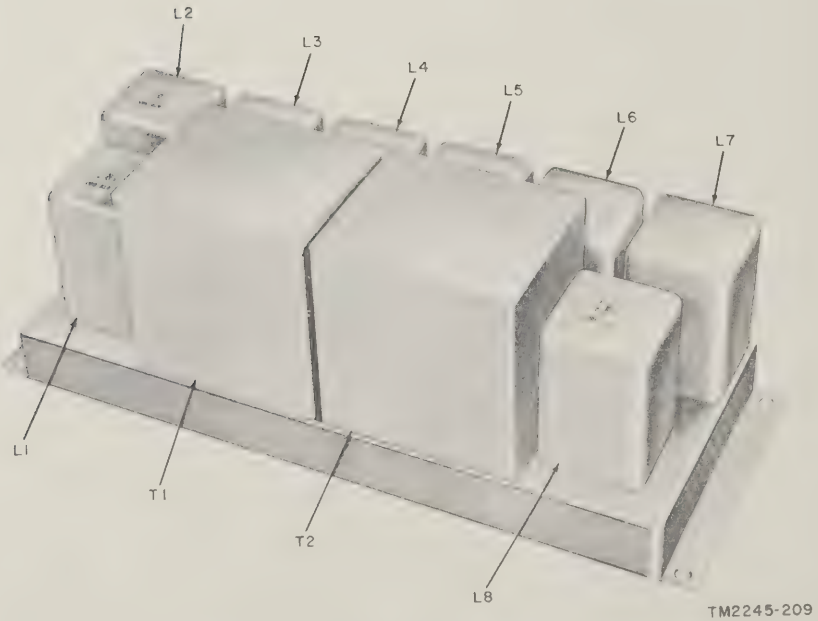



*Figure 225. Transformer reactor assembly, top view.*

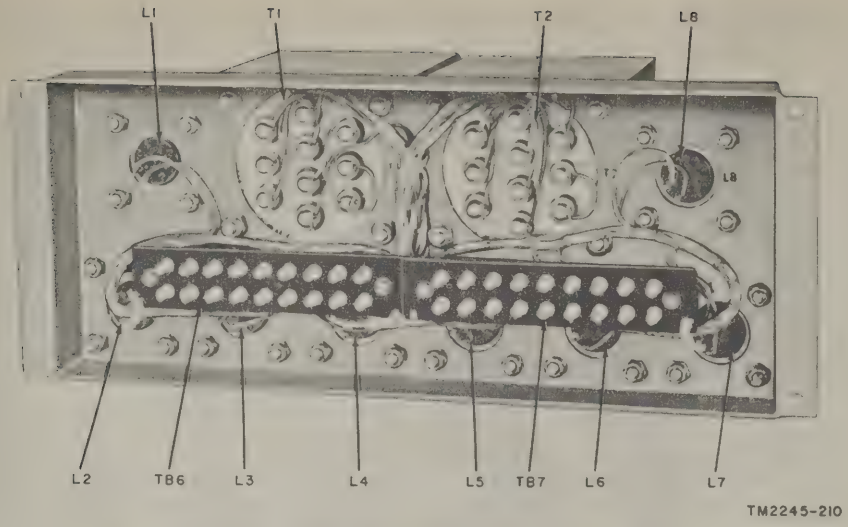



*Figure 226. Transformer reactor assembly, bottom view.*

## Section XV. TROUBLESHOOTING, AC POWER SWITCHING PANEL

### 310. Operational Test, AC POWER SWITCHING PANEL

The general procedure to be followed in performing an operational test is described in paragraph 239*b*. To determine if the AC POWER SWITCHING PANEL is functioning properly, perform the tests described below.

*a. Test Setup.* The AC POWER SWITCHING PANEL remains in place as installed and connected to its normal power. To reach the input and output connections, first remove the drawer-type component located just below the AC POWER SWITCHING PANEL. (In cabinet 2, remove the LEVEL CONTROL & PLATE SUPPLY. In cabinet 4, remove RECEIVER CHANNEL 1. In cabinet 6, remove RECEIVER CHANNEL 11.) Loosen the two screws that hold the rear cover of the AC POWER SWITCHING PANEL (fig. 227) and slide the cover off. Use multimeter TS–352/U for this test.

*b. Test Procedure.* Perform the tests in (1) through (9) below.

(1) Set the multimeter on the 250-volt ac scale, and connect it between terminals 7 and 8 on terminal board TB1 of the AC POWER SWITCHING PANEL. The multimeter should read 115 volts ±5 volts. This is an input connection, therefore if an incorrect reading is obtained, check the power source and the 115 volt ac connection (terminal 3) on transformer T1 in the associated main power unit.

(2) Momentarily connect the multimeter leads to the contacts of each of the 115 V AC UTILITY OUTLETS on the front panel. In each case the reading should be the same as that obtained as instructed in (1) above.

(3) Connect the multimeter between terminals 6 and 8 on terminal board TB1. The multimeter should read 230 volts ±20 volts. This is an input connection; therefore if an incorrect reading is obtained, check the power source and the 230-volt ac connection (terminal 6) on transformer T1 in the associated main power unit.

(4) Set the OUTPUT VOLTAGE switch on the front panel to the UNREG position, and connect the multimeter between terminals 4 and 5 of terminal board TB1. The multimeter reading should be the same as that obtained as instructed in (3) above. See that the OUTPUT VOLTAGE meter M1 shows the same reading of ±7 volts.

(5) Set the VOLTAGE REGULATOR switch to the ON position and connect the multimeter between terminals 2 and 3 on terminal board TB1. The multimeter reading should be the same as that obtained as instructed in (3) above.

(6) With the multimeter connected as instructed in (5) above, set the VOLTAGE REGULATOR switch to OFF. The multimeter should indicate zero voltage. Restore the VOLTAGE REGULATOR switch to the ON position.

(7) Connect the multimeter between terminals 4 and 5 on terminal board TB1 of the AC POWER SWITCHING PANEL and set the OUTPUT VOLTAGE switch to the REG position. The multimeter should read 230 volts ±7 volts. This is a regulated voltage input connection; therefore, if an incorrect reading is obtained, check the associated voltage regulator. Check that OUTPUT VOLTAGE meter M1 shows the same reading ±7 volts.

(8) Set the OUTPUT VOLTAGE switch in the UNREG position and connect the multimeter between terminals 1 and 2 on terminal board TB1 of the AC POWER SWITCHING PANEL. The multimeter should read not more than 5 volts greater than the reading obtained as instructed in (7) above.

*Note.* When starting the voltage regulator, place the OUTPUT VOLTAGE switch in the UNREG position until the voltage regulator warms up. Then switch to the REG position to pick up the load.

(9) Disconnect the multimeter. Replace the cover on the AC POWER SWITCHING PANEL and replace the drawer-type chassis which was removed as instructed in *a* above.

(10) After performing the operational test, check the voltage regulator in accordance with the instructions in paragraph 84 before returning it to service.

## 311. AC POWER SWITCHING PANEL, Troubleshooting Chart

(fig. 227)

The following chart is supplied as an aid in locating trouble in the AC POWER SWITCHING PANEL. This chart lists the symptoms that can be observed when sectionalizing trouble in Telegraph Terminal AN/FGC–29. The chart also lists the probable cause of a symptom and gives the localization procedures to be used to correct it.

| Symptom | Probable trouble | Correction |
|---|---|---|
| 1. No output voltage, OUTPUT VOLTAGE switch in REG position. | *a.* Ac power failure. | *a.* Check for 230 v ac on terminals 6 and 8 of terminal board TB1. If present, perform trouble localization tests on AC POWER SWITCHING PANEL (par. 312). If absent, check ac power source. |
| | *b.* VOLTAGE REGULATOR switch S1 in OFF position. | *b.* See that VOLTAGE REGULATOR switch S1 is in the ON position. |
| | *c.* No output from voltage regulator. | *c.* Check 230V AC REGULATOR INPUT fuses F1 and F2 and indicators I 1 and I 2. Check for 230 v ac on terminals 1 and 2 of terminal board TB1. If present, perform trouble localization tests (par. 312). If absent, check voltage regulator (par. 315). |
| 2. No output voltages, OUTPUT VOLTAGE switch in UNREG position. | *a.* Ac power failure. | *a.* Check for 230 v ac on terminals 6 and 8 of terminal board TB1. If absent, check power source. |
| | *b.* Failure of wiring or switch S2. | *b.* Perform trouble localization tests on AC POWER SWITCHING PANEL (par. 312). |
| 3. No power at utility outlets. | *a.* Ac power failure. | *a.* Check for 115 v ac on terminals 7 and 8 of terminal board TB1. |
| | *b.* 115 V AC UTILITY fuses blown. | *b.* Check fuses F3 and F4 and indicators I 3 and I 4. |

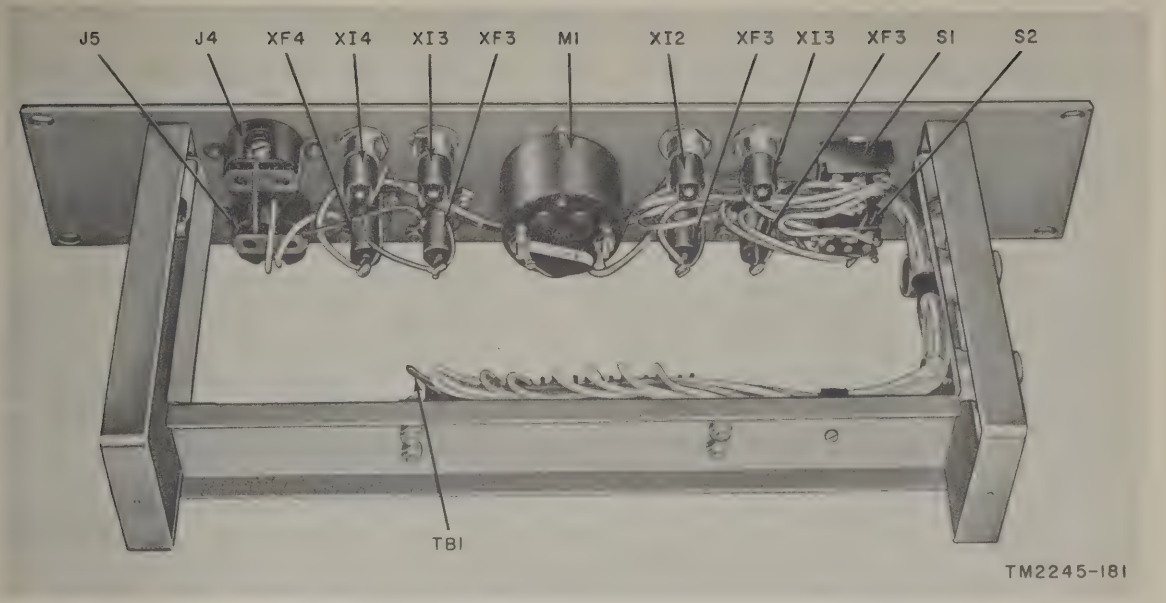



*Figure 227. AC POWER SWITCHING PANEL, rear view.*

## 312. Trouble Localization, AC POWER SWITCHING PANEL

(fig. 227)

The general procedure for localizing trouble is described in paragraph 239*c*. To trace trouble in the AC POWER SWITCHING PANEL, check the wiring, switches, and fuses. To localize trouble in this component, make the measurements listed in the table below with Multimeter TS–352/U and with OUTPUT VOLTAGE switch S2 in the REG position and VOLTAGE REGULATOR switch S1 in the ON position. Trace the power circuit under test on the ac voltage distribution schematic diagrams for the transmitting terminal (fig. 260) and for the receiving terminal (fig. 261). To check the actual wiring, refer to the AC POWER SWITCHING PANEL wiring diagram (fig. 291).

| Test No. | Multimeter TS–352/U probe connections | Normal reading (volts ac) | Corrective measures |
|---|---|---|---|
| 1 | Terminal board TB1, terminals 6 and 8 | 230 | Check ac power source and wiring. |
| 2 | Terminal board TB1, terminals 7 and 8 | 115 | Check ac power source and wiring. |
| 3 | Terminal board TB1, terminals 2 and 3 | 230 | Check fuses F1 and F2 ind indicators I 1 and I 2. Check switch S1. Check wiring between terminal pairs 2, 3 and 6, 8 on terminal board TB1. |
| 4 | Terminal board TB1, terminals 1 and 2 | 230 | Perform trouble localization tests on voltage regulator (par. 315). Check wiring to voltage regulator. Check fuses F1 and F2 and indicators I 1 and I 2. Check switch S1. |
| 5 | Terminal board TB1, terminals 4 and 5 (OUTPUT VOLTAGE switch in REG position). | 230 | Check switch S2 and wiring to voltage regulator. |
| 6 | Terminal board TB1, terminals 4 and 5 (OUTPUT VOLTAGE switch in UNREG position). | 230 | Check switch S2. |
| 7 | Terminals of utility outlets J4 and J5 | 115 | Check fuses F3 and F4 and indicators I 3 and I 4. Check wiring. |

## 313. Operational Test, Voltage Regulator

The general procedure to be followed in making an operational test is described in paragraph 239*b*. To determine if a voltage regulator is functioning properly perform the tests described in *a* and *b* below. The voltage regulators are located in cabinets 2, 4, and 6.

*a. Test Setup.* The voltage regulator remains in place connected to its normal input and output connections as installed. To reach to the regulator, loosen the four captive screws on the front cover panel, remove the panel and place it to one side. It is not necessary to disconnect the flexible cable connected to connector J136. Use Multimeter TS–352/U and the OUTPUT VOLTAGE meter of the associated AC POWER SWITCHING PANEL for the test described in *b*.

*b. Test Procedure.* Perform the test described in (1) through (8) below. Refer to the schematic diagram for the voltage regulator (fig. 144).

(1) See that the VOLTAGE REGULATOR switch on the AC POWER SWITCHING PANEL associated with the voltage regulator under test is in the ON position, and that the OUTPUT VOLTAGE switch is in the REG position.

(2) Set Multimeter TS–352/U to the 250-volt ac range and connect it to terminals 1 and 2 on terminal board TV1 of the voltage regulator. The multimeter should read 230 volts ac ±10 volts. This is an input voltage; therefore an incorrect reading indicates trouble elsewhere in the power distribution circuit.

(3) See that the output voltage, as measured on the OUTPUT VOLTAGE meter on the associated AC POWER SWITCHING PANEL, is adjustable between 220 and 240 volts ac by the VOLTS ADJ control on the voltage regulator. Reset the VOLTS ADJ control for exactly 230 volts ac as indicated by the OUTPUT VOLTAGE meter.

(4) Connect the multimeter between terminals 3 and 4 of terminal board TB1. The multimeter should read 230-volt ac ±7 volts. Note the exact reading.

(5) Check the performance of the voltage regulator by placing the OUTPUT VOLTAGE switch on the associated AC POWER SWITCHING PANEL to the UNREG position. The multimeter reading should not increase more than 5 volts from the reading noted in (4).

(6) Disconnect the multimeter from terminal board TB1 and replace the front-cover panel.

## 314. Voltage Regulator, Troubleshooting Chart

(figs. 228–230)

The following chart is supplied as an aid in locating trouble in the voltage regulator. This chart lists the symptoms that can be observed when sectionalizing trouble in Telegraph Terminal AN/FGC–29. The chart also lists the probable cause of a symptom and gives the localization procedures to be used to correct it. After the trouble has been localized to a circuit in the voltage regulator, voltage and resistance measurements should be sufficient to locate the trouble. The voltage and resistance measurements are given in tabular form in paragraph 316. If the troubleshooting chart indicates the specific circuit in which the trouble is likely to be found, trouble localization should begin with the test indicated by the paragraph reference in the Correction column. Otherwise the trouble localization procedures should begin with the first step given in paragraph 315.

| Symptom | Probable trouble | Correction |
|---|---|---|
| 1. No output voltage | *a.* Ac power failure | *a.* Check for 230 v ac on terminals 1 and 2 of terminal board TB1. If absent, check fuses in AC POWER SWITCHING PANEL and see that VOLTAGE REGULATOR switch is set in ON position. |
| | *b.* Failure of part or wiring in power circuit of regulator. | *b.* Perform trouble localization tests of voltage regulator (par. 315). |
| 2. Output voltage out of limits | *a.* Failure of tubes in control circuit. | *a.* Check tubes V1 and V3. See that tube V2 is lighted; if not, replace tube. |
| | *b.* Failure of control circuit fuse F1. | *b.* Check fuse F1 (on front of chassis). Replace if blown. If replaced fuse blows, proceed with trouble localization test (par. 315). |
| | *c.* Failure of part or wiring in control circuit. | *c.* Perform trouble localization tests of voltage regulator (par. 315). |
| | *d.* Input voltage out of limits | *d.* See that input voltage is between 220 and 240 volts ac. |
| | *e.* Improper setting of VOLTS ADJ control (where output voltage is not more than 10 volts out of limits). | *e.* Reset VOLTS ADJ resistor R16 to provide 230 v ac output. |
| 3. Poor regulation | *a.* Faulty tubes | *a.* Check tubes V1, V2, and V3. Replace if necessary. |
| | *b.* Failure of part or wiring in control circuit. | *b.* Perform trouble localization tests for voltage regulator (par. 315). |

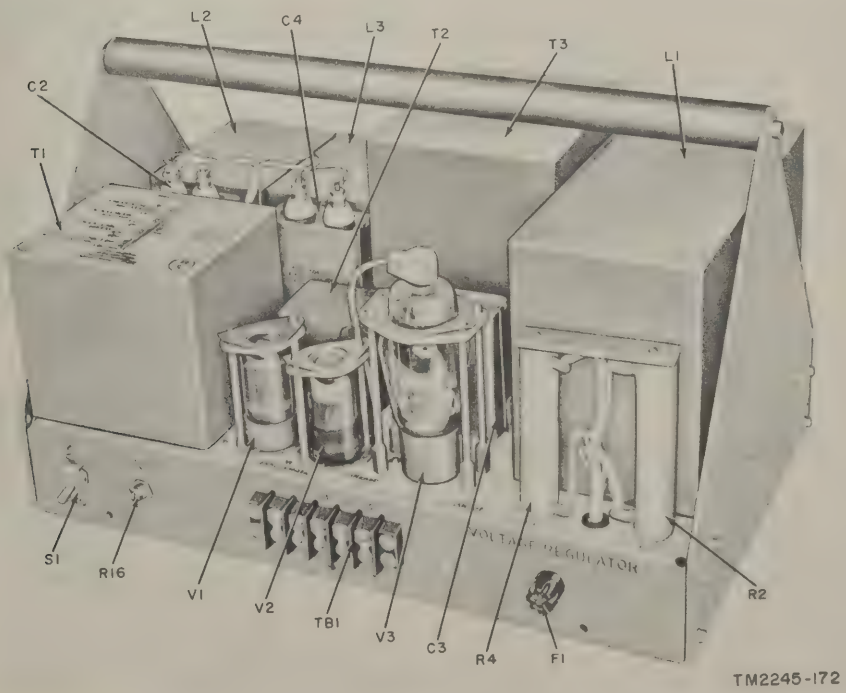



*Figure 228. Voltage regulator, front view.*

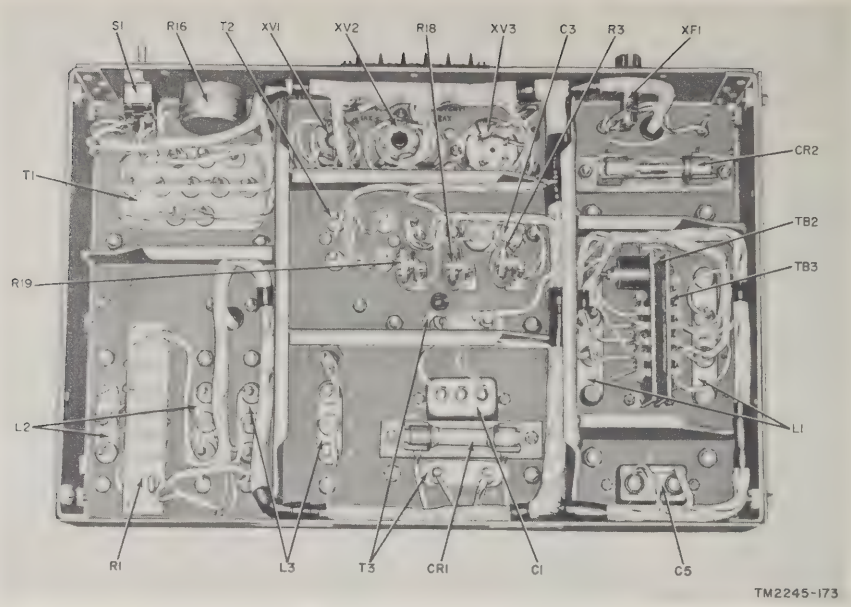



*Figure 229. Voltage regulator, bottom view.*

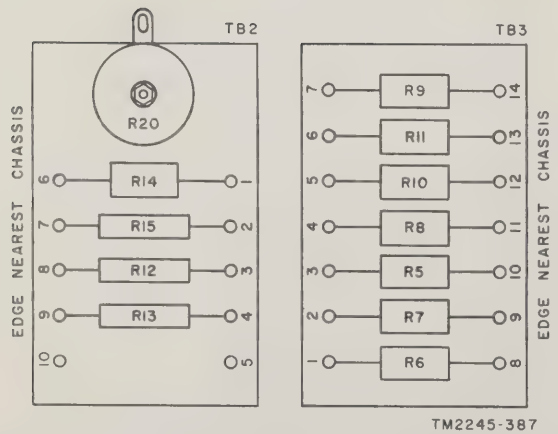



*Figure 230. Voltage regulator, terminal boards TB2 and TB3.*

## 315. Trouble Localization, Voltage Regulator

(figs. 228–230)

The general procedure for localizing trouble is described in paragraph 239*c*. To localize the trouble in the voltage regulator, set up the equipment as indicated in *a* and make the measurements listed in *b* with Multimeter TS–352/U. Refer to the voltage regulator schematic diagram (fig. 144). To check the actual wiring, refer to the voltage regulator wiring diagram (fig. 292).

*a. Test Setup.* Follow the procedure given in (1) through (3) below preparatory to localizing trouble in the voltage regulator.

(1) Place the OUTPUT VOLTAGE switch on the associated AC POWER SWITCHING PANEL in the UNREG position and the VOLTAGE REGULATOR switch to the OFF position.

(2) Remove the voltage regulator from its cabinet for testing without disconnecting the four leads to terminal board TB1 (par. 245*c*).

(3) Place the VOLTAGE REGULATOR switch to the ON position. Do not change the position of the OUTPUT VOLTAGE switch.

*b. Localization Tests, Voltage Regulator.* Follow the procedure given in the table below to localize trouble in the voltage regulator.

| Test No. | Multimeter TS–352/U probe connections | Normal reading (volts) | Corrective measures |
|---|---|---|---|
| 1 | Transformer T3, terminals 1 and 4 | 300 ac | Check wiring from terminals 1 and 2 of terminal board TB1 to transformer T3 and inductor L1. Check wiring between terminal 1 of transformer T3 and inductor L1. Check ac winding of inductor L1 (par. 316*a*). Check transformer T3 (par. 316*a*). Check inductors L2 and L3 (par. 316*a*). Check switch S1 and capacitors C2 and C3. |
| 2 | Terminal board TB1, terminals 3 and 4. | 230 ac | Check resistor R1 and wiring between transformer T3 and terminal 3 of terminal board TB1. Check resistor R2 and associated wiring. |
| 3 | Transformer T1, terminals 1 and 2 | 230 ac | Check resistor R3. Check wiring between resistor R3 and fuse F1. Check safety link V2B (part of tube V2). Check wiring between terminal 2 of transformer T1 and terminal 4 of tube socket XV2. Check wiring between terminal 3 of tube socket XV2 and terminal 2 of terminal board TB1. |
| 4 | Transformer T2, terminals 1 and 2 | 0.63 | Check wiring between terminal 1 of transformer T2 and resistor R1. Check wiring between terminal 2 of transformer T2 and fuse F1. Check resistors R1 and R3. |
| 5 | Tube socket XV1, terminals 2 and 8 | 5 ac | Check winding between terminals 6 and 7 of transformer T1 (par. 316). |
| 6 | Tube socket XV1, terminals 4 and 6 | 720 ac | Check windings between terminals 3, 4, and 5 of transformer T1 (par. 316). |
| 7 | Tube socket XV1, terminals 6 or 4 and ground. | 360 ac | See that terminal 4 of transformer T1 is grounded. |
| 8 | Tube socket XV3, terminals 1 and 5 | 6.3 ac | Check winding between terminals 10 and 11 of transformer T1 (par. 316). |
| 9 | Saturable reactor L1, terminal 4 and ground. | +450 dc | Check rectifier tube V1. |
| 10 | Tube socket XV3, cap and ground | +440 dc | Check dc winding (terminals 4 and 5) of inductor L1 (par. 316). |
| 11 | Tube socket XV3, terminal 2 and ground. | +280 dc | Check resistors R4, R9, R10, and R11. |
| 12 | Tube socket XV3, terminal 3 and ground. | −15 to −35 dc | Check selenium rectifier CR2 and resistors R5 through R8 and R12 through R20. Check tube V2 and capacitors C1 and C5. |
| 13 | Tube socket XV2, terminal 2 and ground. | −400 dc | Check selenium rectifier CR1, resistors R14 through R20 and capacitor C5. |

## 316. Additional Troubleshooting Information, Voltage Regulator

*a. Typical Resistance Readings.* The resistance of transformers and inductors are measured with all connections removed from the terminals. The resistance at the terminals of tube sockets are measured with the connections intact and all conditions normal except that the power is disconnected from the component. Typical resistance measurements are given in the chart that follows:

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Transformers: | | | |
| T1 | 1 | 2 | 11 |
| | 3 | 5 | 160 |
| | 6 | 7 | .075 |
| | 8 | 9 | .037 |
| | 10 | 11 | .150 |
| T2 | 1 | 2 | .23 |
| | 3 | 4 | .0065 |
| T3 | 1 | 4 | 1.8 |

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Inductors: | | | |
| L1 | 1 | 1 | 3.7 |
| | 2 | 2 | 4.1 |
| | 3 | 3 | 4.6 |
| | 4 | 5 | 2,800 |
| L2 | 1 | 3 | 4.4 |
| | 4 | 5 | .065 |
| | 5 | 6 | .13 |
| L3 | 1 | 3 | 4.5 |
| | 4 | 5 | .08 |
| | 5 | 6 | .17 |
| Tube sockets: | | | |
| XV1 | 2 | Ground | 70,000 |
| | 6, 4 | Ground | 78 |
| XV3 | Cap | Ground | 70,000 |
| | 1, 4 | Ground | 0 |
| | 2 | Ground | 23,000 |

*b. Typical Voltage Readings.* Voltages are measured with the component connected to its regulator power supply with tubes in place and all conditions normal. Typical voltage readings for the voltage regulator are given in the chart below.

| Item | Measure from terminal | Measure to terminal | Voltage (volts) |
|---|---|---|---|
| Transformers: | | | |
| T1 | 1 | 2 | 230 ac |
| | 6 | 7 | 5 ac |
| | 10 | 11 | 6.3 ac |
| | 8 | 9 | 2.5 ac |
| T2 | 1 | 2 | .63 ac |
| | 3 | 4 | .2 ac |
| Tube sockets: | | | |
| XV1 | 2, 8 | Ground | +405 dc |
| | 2 | 8 | 5 ac |
| | 4, 6 | Ground | 360 ac |
| XV2 | 2 | 7 | 2.5 ac |
| | 2, 7 | Ground | −400 dc |
| | 5 | Ground | −20 to −35 dc |
| XV3 | Cap | Ground | +440 dc |
| | 2 | Ground | +280 dc |
| | 3 | Ground | −15 to −35 dc |
| | 1, 4 | Ground | 0 |

## Section XVII. TROUBLESHOOTING, LOOP BATTERY PANEL

### 317. Operational Test, LOOP BATTERY PANEL

To determine if a LOOP BATTERY PANEL is functioning properly, check the distribution of 115 volt ac power input and the −130-volt loop battery output of the associated loop battery supplies.

*a. Test Setup.* The LOOP BATTERY PANEL remains in place and connected to its normal ac power source as installed. Set LOAD A fallback switch to the RECT A position and the LOAD B fallback switch to the RECT B position. When testing the LOOP BATTERY PANEL in the transmitting terminal, ground all external transmitting telegraph loops, set all LOOP TERMINATION switches of the transmitters in the GRD position, and set all DIVERSITY switches in the 2 CHANNEL LOOPS 1 & 2 position. When testing the LOOP BATTERY PANEL in the receiving terminal, ground all external receiving telegraph loops and set all IDLE-NORMAL switches of the combiners in the IDLE position. Use Multimeter TS–352/U for checking voltages.

*b. Ac Power Distribution.* Proceed as follows to check the distribution of 115-volt ac power to the loop battery supplies (RECTIFIER A and RECTIFIER B).

(1) Disconnect the plugs from connectors J2 and J3 at the rear of the LOOP BATTERY PANEL.

(2) Connect the multimeter (set on the 250-volt ac range) between the two terminals of connector J2. The multimeter should read 115 volts ac ±5 volts.

(3) Connect the multimeter between the two terminals of connector J3. The multimeter should read 115 volts ac ±5 volts.

(4) Reconnect plug P1 of RECTIFIER A to connector J2 and plug P1 of RECTIFIER B to connector J3.

(5) Momentarily remove first one and then the other of the RECTIFIER A INPUT FUSES on the LOOP BATTERY PANEL. The associated blown fuse indicator should glow and the RECTIFIER A FAILURE INDICATOR also should glow.

(6) Repeat the procedure in (5) for RECTIFIER B.

*c. Loop Battery Distribution.* Proceed as follows to check the distribution of the −130-volt loop battery from RECTIFIER A and RECTI-

FIER B to the output of the LOOP BATTERY PANEL.

(1) Remove the plug from connector J1 at the rear of the LOOP BATTERY PANEL.

(2) Arrange Multimeter TS–352/U to read on the 250 volt dc scale. Connect the positive (+) lead of the multimeter to contact T (ground) on connector J1.

(3) Successively connect the negative (−) lead of the multimeter to contacts A through S on connector J1 of the LOOP BATTERY PANEL and check for −135 volts dc ±5 volts.

(4) Reconnect the plug to connector J1.

(5) Remove loop fuses 8 and 9. The associated BLOWN FUSE INDICATORS should glow.

(6) Change the LOAD A switch to the RECT B position and the LOAD B switch to the RECT A position. The BLOWN FUSE INDICATORS should continue to glow.

(7) Set the FALL BACK SWITCHES to their original positions. Replace loop fuses 8 and 9 in their holders.

## 318. LOOP BATTERY PANEL, Troubleshooting Chart

(fig. 231)

The following chart is supplied as an aid in locating trouble in the LOOP BATTERY PANEL. This chart lists the symptoms that can be observed when sectionalizing trouble in Telegraph Terminal AN/FGC–29. The chart also lists the probable cause of a symptom and gives the localization procedures to be used to correct it. If the troubleshooting chart indicates the specific subassembly or circuit in which the trouble is likely to be found, trouble localization should begin with the test indicated by the paragraph reference in the Correction column. Otherwise, the trouble localization procedures should begin with the first step given in paragraph 319.

| Symptom | Probable trouble | Correction |
|---|---|---|
| 1. No loop battery voltage to either LOAD A or LOAD B. | Ac power failure | Check ac power source. Check fuses F19 through F22 and indicators I 19 through I 22. Check ac power connector J6. |
| 2. No loop battery voltage to LOAD A. | *a.* Failure of ac power to RECTIFIER A. | *a.* Check fuses F19 and F20 and indicators I 19 and I 20. Check for 115 v ac at connector J2. |
| | *b.* Failure of RECTIFIER A. | *b.* Perform trouble localization tests for loop battery supply (par. 322). |
| | *c.* Failure of part or wiring between connector J4 and fuses F1 through F8. | *c.* Check connector J4. Perform trouble localization tests for LOOP BATTERY PANEL (par. 319). |
| 3. No loop battery voltage to LOAD B. | *a.* Failure of ac power to RECTIFIER B. | *a.* Check ac fuses F21 and F22 and indicators I 21 and I 22. Check for 115 v ac at connector J3. |
| | *b.* Failure of RECTIFIER B. | *b.* Perform trouble localization tests for loop battery supply (par. 322). |
| | *c.* Failure of part or wiring between connector J5 and fuses F9 through F16. | *c.* Check connector J5. Perform trouble localization tests on LOOP BATTERY PANEL (par. 319). |
| 4. No loop battery to any individual loop (loops 1–16). | *a.* Failure of associated loop fuse (F1–F16). | *a.* Check associated loop fuse of failed loop. |
| | *b.* Failure of part or wiring between loop fuse and connector J1. | *b.* Perform trouble localization tests for LOOP BATTERY PANEL (par. 319). |

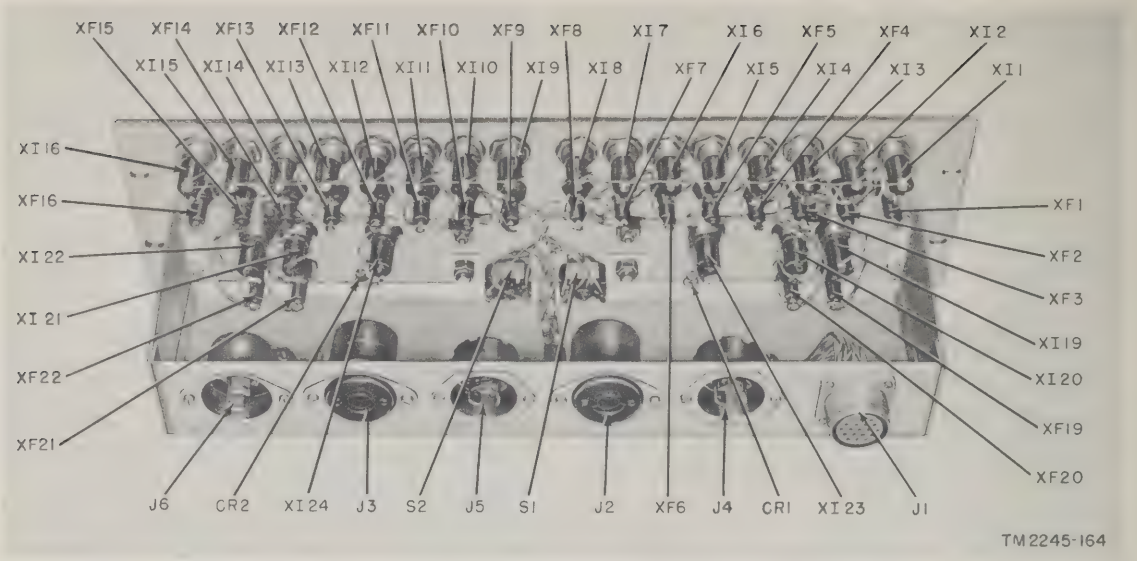



*Figure 231. LOOP BATTERY PANEL, rear view from above.*

## 319. Trouble Localization, LOOP BATTERY PANEL

(fig. 231)

The general procedure for localizing trouble is described in paragraph 239*c*. To localize trouble in the LOOP BATTERY PANEL make the measurements listed below by using Multimeter TS–352/U. Refer to the schematic diagram of the LOOP BATTERY PANEL (fig. 149). Also refer to the ac power distribution diagram for the transmitting terminal (fig. 260) and for the receiving terminal (fig. 261). The loop battery distribution is shown for the transmitting terminal in figure 147 and for the receiving terminal in figure 148. To check the wiring, refer to the wiring diagram of the LOOP BATTERY PANEL (fig. 293). Measurements are taken with the LOAD A switch in the RECT A position and the LOAD B switch in the RECT B position. If difficulty is encountered in reaching any part, it may be necessary to remove the LOOP BATTERY PANEL from the cabinet (par. 245*d*).

| Test No. | Multimeter TS-352/U probe connections | Normal reading (volts) | Corrective measures |
|---|---|---|---|
| 1 | Connector J2 | 115 ac | Check fuses F19 and F20 and indicators I 19 and I 20. Check wiring from connector J6 to connector J2. |
| 2 | Connector J3 | 115 ac | Check fuses F21 and F22 and indicators I 21 and I 22. Check wiring from connector J6 to connector J3. |
| 3 | Switch S1, terminal 3 and ground | −130 dc | See that plug P2 is properly engaged in connector J5. Check RECTIFIER B (par. 320). |
| 4 | Switch S2, terminal 1 and ground | −130 dc | See that plug P2 is properly engaged in connector J4. Check RECTIFIER A (par. 320). |
| 5 | Switch S1, terminal 2 and ground | −130 dc | Check switch S1. |
| 6 | Switch S2, terminal 2 and ground | −130 dc | Check switch S2. |
| 7 | Fuses F1 through F16, ring terminal and ground. | −130 dc | Check fuses F1 through F16 and indicators I 1 through I 16. |

## 320. Operational Test, Loop Battery Supply

The general procedure to be followed in performing an operational test is described in paragraph 239*b*. To test a loop battery supply, check its output voltage at no load and at full load.

*a. Test Setup.* Remove the loop battery supply from the cabinet (par. 245*e*) and stand it upend to reach the underside of the chassis. Use Multimeter TS–352/U and Electronic Multimeter ME–6A/U for the tests.

*b. No-load Test.* To check the no-load characteristics of the loop battery supply, proceed as follows:

(1) Connect ac power plug P1 to the appropriate connector (J2 or J3) at the rear of the LOOP BATTERY PANEL. Relay K1 should operate approximately 20 seconds after the connection is made.

(2) Connect the positive (+) lead of the multimeter (set on 250-volt dc range) to the large contact on dc power plug P2. Connect the negative (—) lead to the adjacent clockwise contact (fig. 150) as viewed from the end. The multimeter should read 135 volts ±9 volts. Record the exact reading.

*c. Full Load Test.* To check the performance of the loop battery supply at full load, provide a 1-ampere load. To do this for the transmitting terminal, close all 16 transmitting loops to ground and set all LOOP TERMINATION switches of the transmitters in the GRD position and all LOOP CURRENT SELECTOR switches in the 60MA position. For the receiving terminal, close all loops to ground and set all IDLE-NORMAL switches of the combiners in the IDLE position and all LOOP CURRENT switches in the 60MA position. Alternatively, an external130-ohm resistive load capable of dissipating approximately 130 watts may be connected across terminals 1 and 2 of terminal board TB1 on the loop battery supply.

(1) If the loops of the transmitters or combiners are to be used to load the loop battery supply then connect dc power plug P2 to the appropriate connector (J4 or J5) at the rear of the LOOP BATTERY PANEL, and set the FALL BACK SWITCHES so that both LOAD A and LOAD B are connected to the RECTIFIER under test. If an external resistive load is to be used, connect it across terminals 1 and 2 of terminal board TB1 in the loop battery supply.

***Caution:*** Disconnect the ac power cord while connecting the external load.

(2) Connect the multimeter between terminals 1 (+) and 2 (—) on terminal board TB1. The multimeter should read within 10 volts of the voltage measured in *b* above.

(3) Connect the electronic multimeter between terminals 1 (ground) and 2 on terminal board TB1 to measure the ac ripple voltage. The reading should be less than 1 volt ac.

(4) Disconnect the multimeter and the external load (if used) from the loop battery supply and restore the FALL BACK SWITCHES to their normal positions.

(5) Disconnect the power cords from the LOOP BATTERY PANEL and slide the loop battery supply back into position.

(6) Reconnect both power cords to their associated connectors on the LOOP BATTERY PANEL and replace the front cover panel.

## 321. Loop Battery Supply, Troubleshooting Chart

(figs. 232 and 233)

The following chart is supplied as an aid in locating trouble in the loop battery supply. This chart lists the symptoms that can be observed when sectionalizing trouble in Telegraph Terminal AN/FGC–29. The chart also lists the probable cause of a symptom and gives the localization procedures to be used to correct it. After the trouble has been localized to a circuit or part in the loop battery supply, voltage and resistance measurements (par. 323) should be sufficient to locate the trouble. If the troubleshooting chart indicates the specific part or circuit in which the trouble is likely to be found, trouble localization should begin with the test indicated by the correction column. Otherwise, the trouble localization procedures should begin with the first step given in paragraph 322.

395139 O—56——26

| Symptom | Probable trouble | Correction |
|---|---|---|
| 1. No output | *a.* Ac power failure | *a.* Check associated INPUT FUSES on LOOP BATTERY PANEL. Check ac power cables W1 and W2 and connectors P1 and P2. |
| | *b.* Failure of rectifier tube V1 | *b.* Check tube V1, and replace if defective. |
| | *c.* Failure of relay K1 | *c.* Perform trouble localization test (par. 322). |
| | *d.* Failure of internal part or wiring. | *d.* Perform trouble localization tests (par. 322). |
| 2. Output voltage incorrect | *a.* Incorrect ac input voltage | *a.* Check for 115 v ac at primary of transformer T1. |
| | *b.* Defective rectifier tube V1 | *b.* Check tube V1, replace if defective. |
| | *c.* Failure of internal part or wiring. | *c.* Perform trouble localization tests (par. 322). |
| 3. Excessive ripple voltage | *a.* Defective filter capacitor or inductor. | *a.* Perform trouble localization tests (par. 322). |

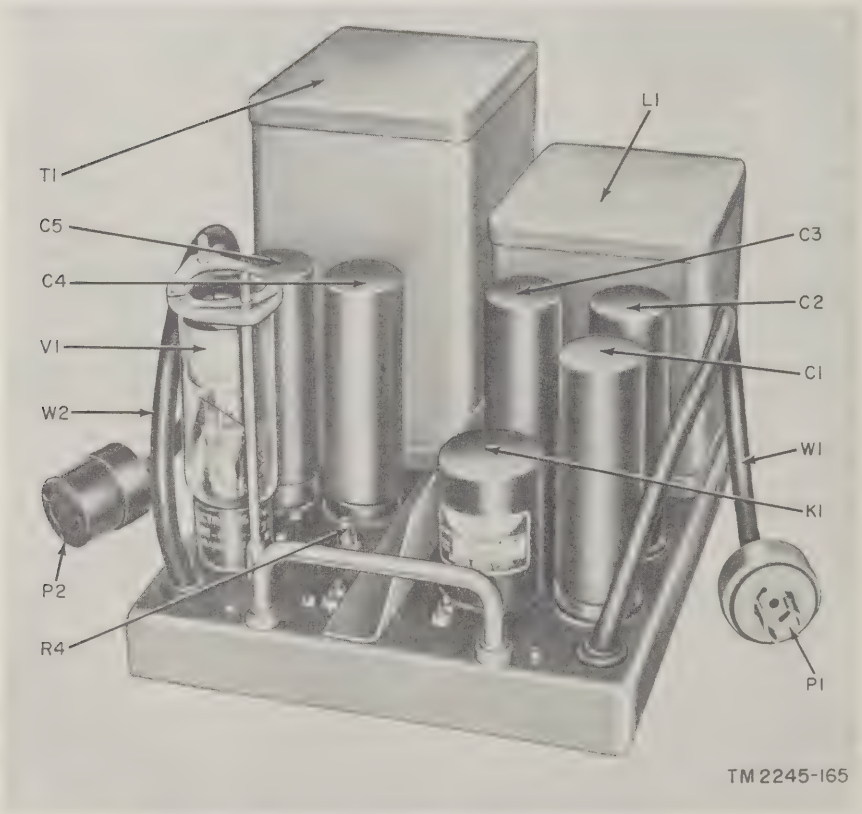



*Figure 232. Loop battery supply, front view.*

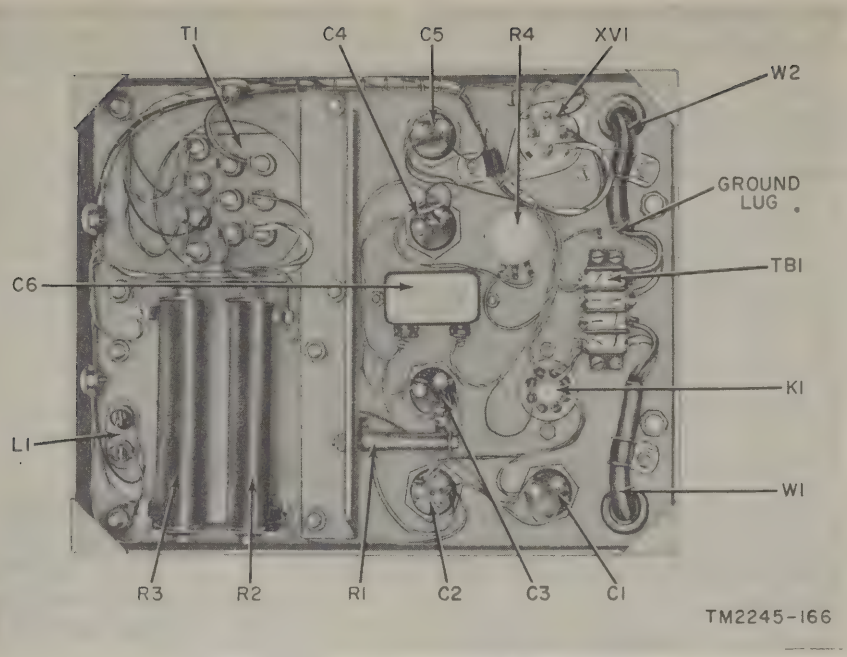



*Figure 233. Loop battery supply, bottom view.*

## 322. Trouble Localization, Loop Battery Supply

(figs. 232 and 233)

The general procedure to be followed in localizing trouble is discussed in paragraph 239*c*. The trouble localization tests for the loop battery supply, when required, are usually performed immediately following the localization tests of the LOOP BATTERY PANEL (par. 319). Make the measurements listed in the table below. Trace the circuit on the loop battery supply schematic diagram (fig. 150). To check the actual wiring, refer to the loop battery supply wiring diagram (fig. 294). The test setup for the localization tests of the loop battery supply is the same as for the full-load operational test for this unit (par. 320*c*).

| Test No. | Multimeter TS-352/U probe connections | Normal reading (volts) | Corrective measures |
|---|---|---|---|
| 1 | Terminal board TB1, terminals 3 and 4 | 115 ac | Check ac power source. Check power cable W1 and plug P1. |
| 2 | Tube socket XV1, terminals 1 and 4 | 2.5 ac | Check transformer T1 (par. 323). |
| 3 | Tube socket XV1, terminals 2 and 3 | 310 ac | Check transformer T1 (par. 323). |
| 4 | Transformer T1, terminal 1 and inductor L1, terminal 2. | −125 dc | Check inductor L1 (par. 323) capacitors C1 through C6. |
| 5 | Relay K1, terminals 1, 2, 7 and ground | −125 dc | Check relay K1. Check capacitors C1 through C5. Check resistors R1 and R2. |
| 6 | Terminal board TB1, terminals 2 and 1 (ground). | 1 ac max | Check capacitors C1 through C6. Check inductor L1 (par. 323). |

## 323. Additional Troubleshooting Information, Loop Battery Supply

*a. Typical Resistance Readings.* The resistances of transformers and inductors are measured with all connections removed from their terminals. Typical resistance measurements are given in the chart below.

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Transformer T1 | 1 | 4 | 5.2 |
| | 5 | 7 | 7.5 |
| | 8 | 10 | .014 |
| | 1 | 2 | 3 |
| | 1 | 8 | 4,800 |

*b. Typical Voltage Readings.* Voltages are measured with the equipment connected to its regular power supply and with all conditions normal. Typical voltage measurements are given in the chart below.

| Item | Measure from terminal | Measure to terminal | Voltage (volts) |
|---|---|---|---|
| Transformer T1 | 5 | 7 | 310 ac |
| | 8 | 10 | 2.5 ac |
| Terminal board TB1 | 1 | 2 | −125 dc |

# Section XIX. TROUBLESHOOTING, TRANSMITTER METER PANEL

## 324. Operational Test, TRANSMITTER METER PANEL

The general procedure for making an operational test is described in paragraph 239*b*. To check the operation of the TRANSMITTER METER PANEL, perform the tests outlined in *a*, *b*, and *c* below. Use external test equipment which is known to be properly calibrated. The TRANSMITTER METER PANEL is tested in place and connected to its normal power supply as installed.

*a. LEVEL METER Circuit.* Check the LEVEL METER circuit with Signal Generator SG–15/PCM as follows:

(1) Set the ATTENUATOR control on the LEVEL METER to 0 and the power ON-OFF switch to ON. Allow a few minutes for the equipment to warm up.

(2) Adjust the frequency of the signal generator to 2,000 cps and connect its OUTPUT jacks to the TERMINATING jacks of the LEVEL METER.

(3) Set the signal generator output level to exactly 0 dbm. The LEVEL METER should read 0 dbm ±.2 db.

*b. LOOP CURRENT METER Circuit.* Check the LOOP CURRENT METER circuit with Multimeter TS–352/U. Use the 0–100-ma dc scale as follows.

(1) Set the MILLIAMPERES switch of the LOOP CURRENT METER to 90, and connect the INPUT jack to the LOOP 1 MONITOR jack of TRANSMITTER CHANNELS 1 and 2.

(2) Set the LOOP CURRENT SELECTOR switch of transmitter channel 1 to the 60MA position and the LOOP TERMINATION switch to the GRD position. Connect the multimeter to the LOOP 1 EQUIP jack. Adjust the CHANNEL 1 LOOP CURRENT ADJUST control until the multimeter reads exactly 60 ma. The LOOP CURRENT METER should read 60 ma ±3 ma on the 90-ma scale.

(3) Set the LOOP CURRENT SELECTOR switch of transmitter 1 to the 20MA position. Adjust the CHANNEL 1 LOOP CURRENT ADJUST control until the multimeter reads exactly 20 ma.

(4) Depress the BIAS switch of the LOOP CURRENT METER and hold it until a reading is obtained. The LOOP CURRENT METER should read 40 ma ±3 ma on the 90-ma scale.

(5) Release the BIAS switch and set the MILLIAMPERES switch to 30. The LOOP CURRENT METER should read 20 ma ±2 ma on the 30-ma scale.

*c. DOTTER Circuit.* Check the DOTTER circuit, which includes a DOT FREQUENCY indicator operating in conjunction with the MARK-SPACE-DOT switch, as follows:

(1) Set the MILLIAMPERES switch of the LOOP CURRENT METER to 90, and connect the INPUT jack to the METER jack of the DOTTER.

(2) Set the LOOP TERMINATION switch of transmitter channel 1 to NEG and the LOOP CURRENT SELECTOR switch to 90 MA.

(3) Turn the MARK-SPACE-DOT switch to MARK, and connect the DOTTER OUTPUT jack to the LOOP 1 EQUIP jack of the transmitter. Adjust the CHANNEL 1 LOOP CURRENT ADJUST control until the LOOP CURRENT METER reads exactly 60 ma.

(4) Set the MARK-SPACE-DOT switch to SPACE. The LOOP CURRENT METER should read 0 ma.

(5) Set the MARK-SPACE-DOT switch to DOT. The LOOP CURRENT METER should read 0 ma.

(6) Depress the BIAS switch of the LOOP CURRENT METER. The meter should read 60 ma ±1 ma.

## 325. TRANSMITTER METER PANEL, Troubleshooting Chart

(figs. 234–237)

The following chart is supplied as an aid in locating trouble in the TRANSMITTER METER PANEL. This chart lists the symptoms that can be observed, the probable cause of a symptom, and gives the procedures to be used to correct it. After the trouble has been localized to a circuit in the LEVEL METER, the LOOP CURRENT METER or the DOTTER in the TRANSMITTER METER PANEL, voltage and resistance measurements (par. 327) should be sufficient to locate the trouble. If the troubleshooting chart indicates the specific subassembly or circuit in which the trouble is likely to be found, trouble localization should begin with the test indicated in the paragraph reference in the *correction* column. Otherwise the trouble localization procedures should begin with the first step given in paragraph 326.

| Symptom | Probable trouble | Correction |
|---|---|---|
| 1. LEVEL METER and DOTTER inoperative. | *a.* Failure of ac power supply. | *a.* Check ac power source. Check power cord and connectors. Check for 115 v ac between terminals 1 and 3 or 2 and 4 of transformers T3 and T4. Check fuses F1 and F2 and indicator lamps I 1 and I 2. |
| 2. LEVEL METER inoperative. | *a.* Failure of B-plus voltage in LEVEL METER. | *a.* Check for +165 v dc at terminal 2 of transformer T2. If absent, perform trouble localization tests of LEVEL METER section of TRANSMITTER METER PANEL (par. 326*b*). |
| | *b.* Failure of heater voltage in LEVEL METER. | *b.* Check for 6.3 v ac between terminals 5 and 6 of transformer T3. If present, check heater circuit continuity. If absent, check transformer T3 (par. 327*a*). |
| | *c.* Defective BRIDGING or TERMINATING jacks. | *c.* Check jacks J1 through J4. |
| | *d.* Defective transformer T1 | *d.* Check transformer T1 (par. 327*a*). |
| | *e.* Defective ATTENUATOR control AT1. | *e.* Check attenuator AT1 (par. 249). |
| | *f.* Failure of amplifier section of LEVEL METER. | *f.* Perform trouble localization on the LEVEL METER of the TRANSMITTER METER PANEL (par. 326*b*). |
| | *g.* Defective transformer T2 | *g.* Check transformer T2 (par. 327*a*). |
| | *h.* Defective meter M1 | *h.* Check meter M1. |
| 3. LOOP CURRENT METER inoperative. | *a.* Defective INPUT jack | *a.* Check INPUT jack J5. |
| | *b.* Defective MILLIAMPERES switch. | *b.* Check MILLIAMPERES switch S3. |
| | *c.* Defective BIAS switch | *c.* Check BIAS switch S4. |
| | *d.* Defective part in LOOP CURRENT METER circuit. | *d.* Perform trouble localization on the LOOP CURRENT METER of the TRANSMITTER METER PANEL (par. 326*c*). |
| | *e.* Defective meter M2 | *e.* Check meter M2. |

| Symptom | Probable trouble | Correction |
|---|---|---|
| 4. DOTTER inoperative | *a.* Failure of −130 v dc in DOTTER. | *a.* Check for −130 v dc at connector J7. Check fuse F3 and indicator I4. |
| | *b.* Failure of heater voltage in DOTTER. | *b.* Check for 6.3 v ac between terminals 5 and 6 of transformer T4. If present, check heater circuit continuity. If absent, check transformer T4 (par. 327). |
| | *c.* Failure of part or wiring in DOTTER. | *c.* Perform trouble localization on the DOTTER in TRANSMITTER METER PANEL (par. 226*d*). |
| | *d.* Defective switch S5 | *d.* Check switch S5. |
| | *e.* Defective METER or OUTPUT jacks. | *e.* Check jacks J8 and J9. |
| 5. LEVEL METER out of limits. | *a.* LEVEL METER out of calibration. | *a.* Adjust resistor R21. Refer to calibration procedure for LEVEL METER (par. 85*a*). |
| | *b.* Defective part in LEVEL METER. | *b.* Perform trouble localization tests for LEVEL METER (par. 326*b*). |
| 6. LOOP CURRENT METER out of limits. | *a.* Defective part in LOOP CURRENT METER circuit. | *a.* Perform trouble localization tests for LOOP CURRENT METER (par. 326*c*). |

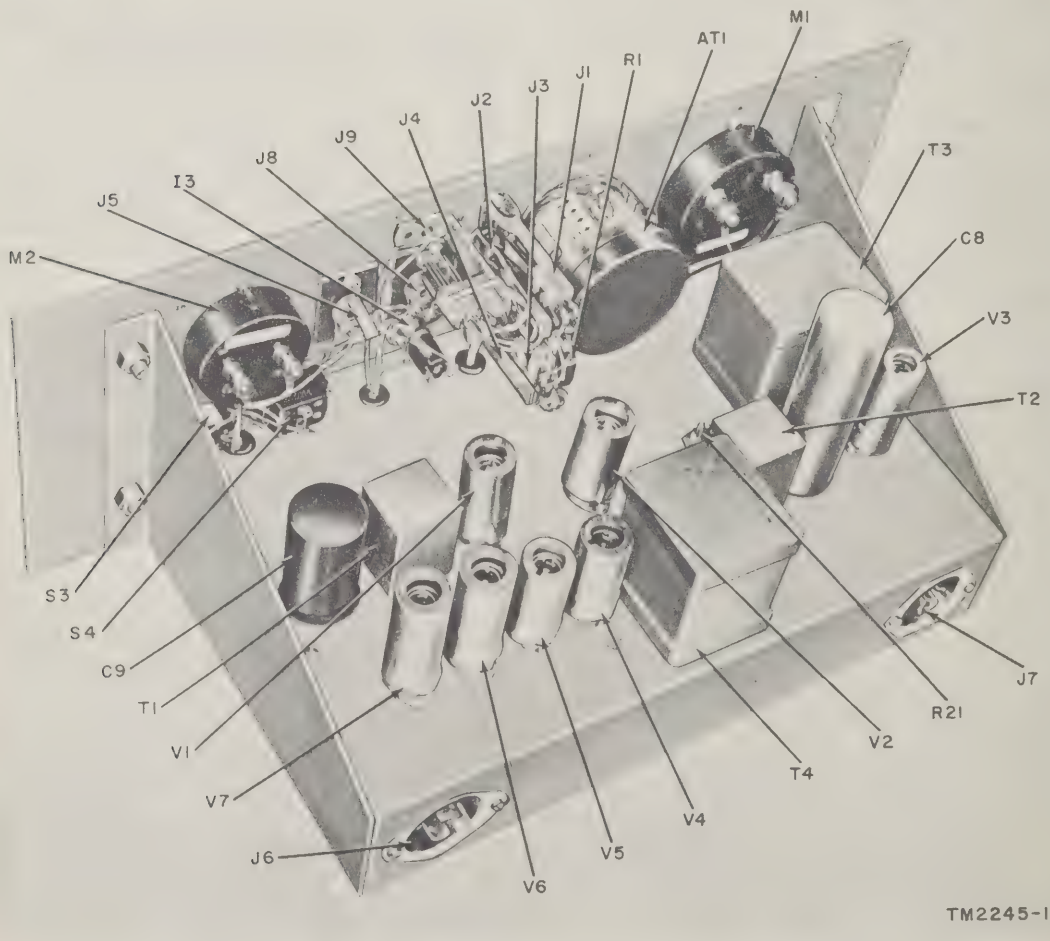



*Figure 234. TRANSMITTER METER PANEL, top view.*

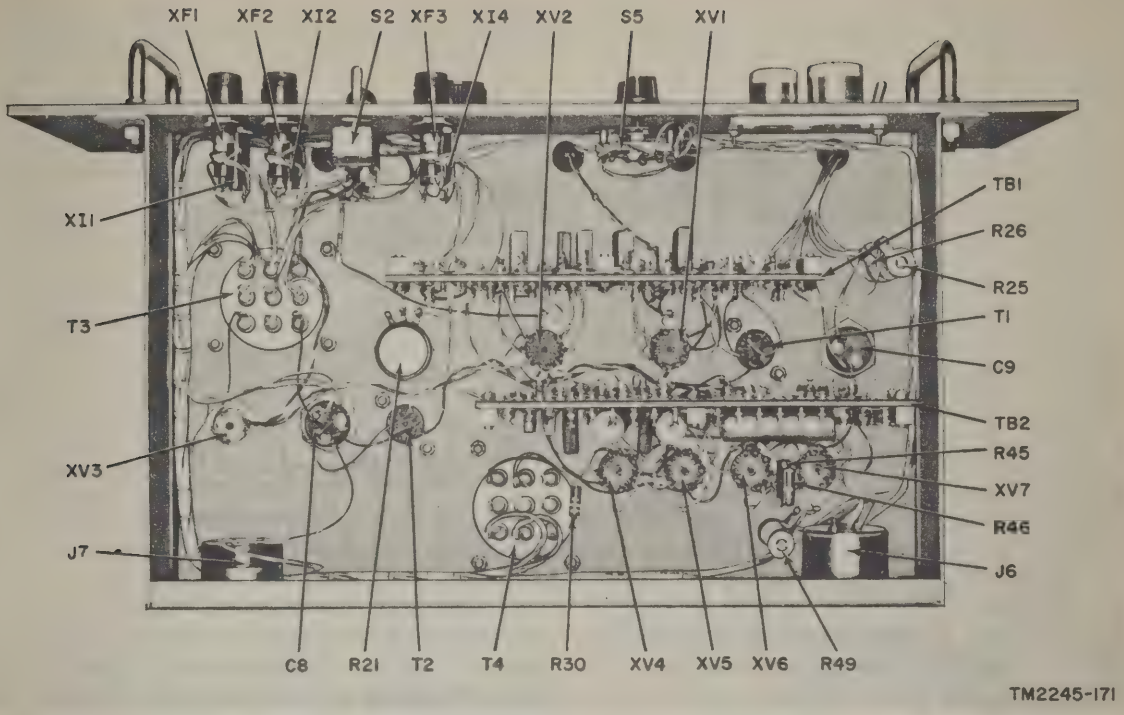



*Figure 235. TRANSMITTER METER PANEL, bottom view.*

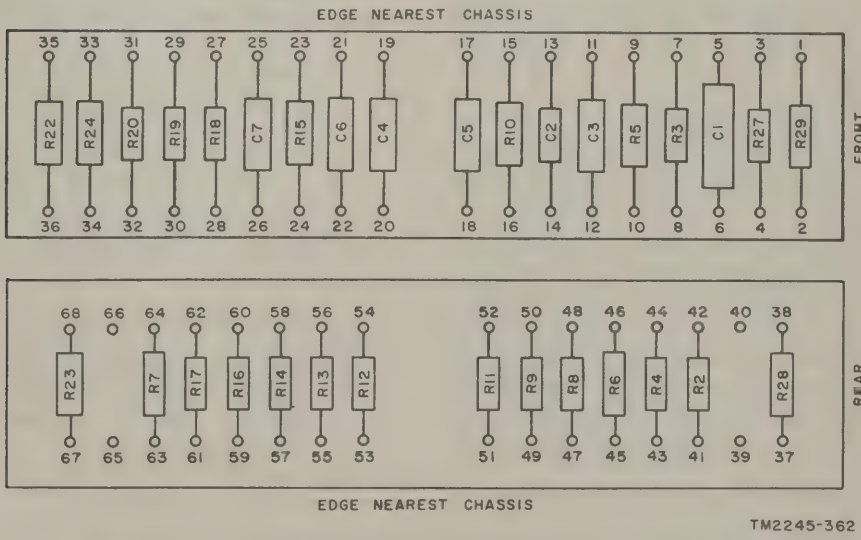



*Figure 236. TRANSMITTER METER PANEL, terminal board TB1.*

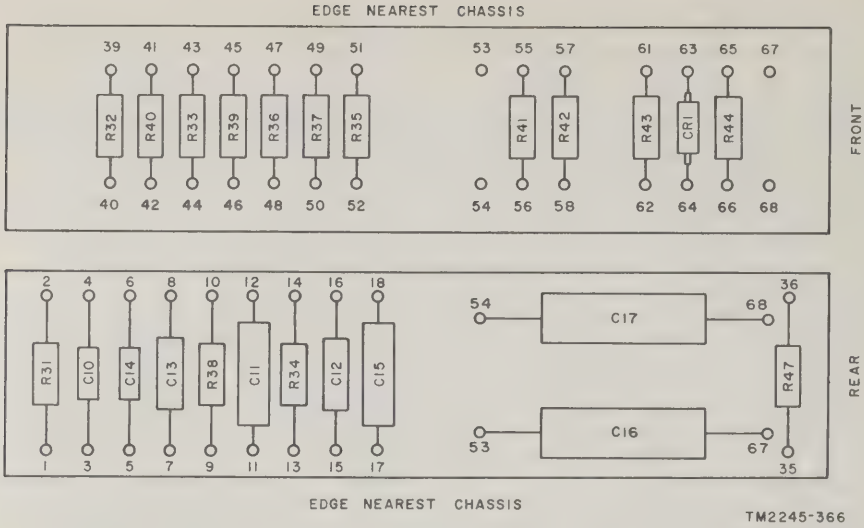



*Figure 237. TRANSMITTER METER PANEL, terminal board TB2.*

## 326. Trouble Localization, TRANSMITTER METER PANEL

(figs. 234–237)

The general procedure for localizing trouble is described in paragraph 239*c*. To trace trouble in the TRANSMITTER METER PANEL, individually test the LEVEL METER, the LOOP CURRENT METER, and the DOTTER. Use Signal Generator SG–15/PCM and Electronic Multimeter ME–6A/U. Trace the circuit under test on the schematic diagram for the TRANSMITTER METER PANEL (fig. 153). To check the actual wiring, refer to the TRANSMITTER METER PANEL wiring diagram (fig. 295).

***Caution:*** In the following tests, do not check meter M1 or M2 with an ohmmeter. The current from the ohmmeter may damage the meters. Replace a suspected meter with a similar meter known to be good. If this clears the trouble, the original meter is defective and should be replaced.

*a. Test Setup.* Remove the TRANSMITTER METER PANEL from cabinet 1 (par. 245*b*). Place the unit on a suitable table at the rear of cabinet 1 so that cabinet plugs P113 and P123 may be connected to connectors J7 and J6, respectively, and the underside of the chassis can be reached.

*b. Localization Tests, LEVEL METER.*

(1) Adjust the frequency of the signal generator to 2,000 cps and the level to 0 dbm.

(2) Connect the OUTPUT jacks of the signal generator to the TERMINATING jacks of the LEVEL METER.

(3) Set the ATTENUATOR control of the LEVEL METER to 0 and the power ON-OFF switch of the TRANSMITTER METER PANEL to the ON position. Allow a few minutes for the equipment to warm up.

(4) The LEVEL METER should read 0 dbm. If it is not possible to attain this reading with adjustment of variable resistor R21, proceed with the localization measurements listed below.

| Test No. | Electronic Multimeter ME–6A/U probe connections | Normal reading (volts ac) | Corrective measures |
|---|---|---|---|
| 1 | Transformer T1, terminals 3 and 4 | .27 | Check jacks J1 through J4. Check resistors R2 and R3 and capacitor C1. Check transformer T1 (par. 327*a*) and attenuator AT1. |
| 2 | Tube socket XV1, terminal 2 and ground | .0091 | Check attenuator AT1 (par. 249) and resistor R4. |

| Test No. | Electronic Multimeter ME-6A/U probe connections | Normal reading (volts ac) | Corrective measures |
|---|---|---|---|
| 3 | Tube socket XV1, terminal 7 and ground | .028 | Check tube V1. Make voltage and resistance measurements at tube socket XV1 (par. 327). Check resistors R5 through R9 and capacitors C2 and C3. |
| 4 | Tube socket XV2, terminal 2 and ground | .12 | Check tube V1. Measure dc voltages and resistances at tube socket XV1 (par. 327). Check resistors R10 through R14. Check capacitors C2 through C6. |
| 5 | Tube socket XV2, terminal 7 and ground | 1.0 | Check tube V2. Make voltage and resistance measurements at tube socket XV2 (par. 327). Check resistors R15 through R17 and capacitor C7. |
| 6 | Transformer T2, terminals 3 and 4 | 1.28 | Check tube V2. Make dc voltage and resistance measurements at tube socket XV2 (par. 327). Check resistors R18 through R21. |
| 7 | Meter M1 terminals | .59 | Check resistors R19, R20, and R21. Check meter M1. |

*c. Localization Tests, LOOP CURRENT METER.*

(1) Set the MILLIAMPERES switch of the LOOP CURRENT METER to the 90 position and connect the INPUT jack to the LOOP 1 MONITOR jack of TRANSMITTER CHANNELS 1 and 2.

(2) Set the LOOP CURRENT SELECTOR switch of transmitter channel 1 on 20 MA and the LOOP TERMINATION switch on GRD.

(3) Adjust the CHANNEL 1 LOOP CURRENT ADJUST control of the transmitter until the LOOP CURRENT METER reads exactly 20 ma. Depress the BIAS switch on the LOOP CURRENT METER. The meter should read 40 ma ±3 ma. If it is not possible to obtain these readings, disconnect meter M2 and check the individual parts, resistors R25 through R29, capacitor C9, switches S3 and S4, jack J5, and meter M2.

*d. Localization Tests, Dotter.* To localize trouble in the dotter, set the MARK-SPACE-DOT switch to the DOT position and make the tests indicated in the chart below.

| Test No. | Electronic Multimeter ME-6A/U probe connections | Normal reading (volts ac) | Corrective measures |
|---|---|---|---|
| 1 | Transformer T4, terminals 7 and 8 | 80 | Check transformer T4 (par. 327*a*). |
| 2 | Tube socket XV4, terminals 1 and 3 | 48 | Check tube V4. Make voltage and resistance measurements at tube socket XV4 (par. 327). Check resistors R30 and R31. |
| 3 | Tube socket XV5, terminal 1 and ground, terminal 6 and ground. | 29 | Check tube V5. Make voltage and resistance measurements at tube socket XV5 (par. 327). Check resistors R32 through R39 and capacitors C10 through C14. |
| 4 | Tube socket XV4, terminal 8 and ground | 11 | Check tube V4. Check capacitor C15 and resistors R41 and R42. |
| 5 | Tube sockets XV6 and XV7, terminal 6 and ground. | 48 | Check tubes V6 and V7. Make voltage and resistance measurements at tube sockets XV6 and XV7 (par. 327). Check diode CR1. Check resistors R43 through R47 and capacitors C16 and C17. |
| 6 | OUTPUT jack J9, tip and ground | 48 | Check switch S5, indicator I 5, and jacks J8 and J9. |

## 327. Additional Troubleshooting Information, TRANSMITTER METER PANEL

*a. Typical Resistance Readings.* The resistance of transformers are measured with all connections removed from their terminals. The resistance at the terminals of the tube sockets are measured with all conditions intact and all conditions

normal except that power is disconnected from the component given in the chart below.

(1) *LEVEL METER.*

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Transformers: | | | |
| T1 | 1 | 2 | 180 |
| | 3 | 4 | 180 |
| T2 | 1 | 2 | 180 |
| | 3 | 4 | 60 |
| T3, T4 | 1 | 3 | 80 |
| | 2 | 4 | 80 |
| | 5 | 6 | 0.45 |
| | 7 | 8 | 160 |
| | 8 | 9 | 150 |
| Tube sockets: | | | |
| XV1 | 3 | Ground | 1,000 |
| | 7 | Ground | 470,000 |
| | 8 | Ground | 1,000 |
| XV2 | 2 | Ground | 470,000 |
| | 3 | Ground | 1,000 |
| | 7 | Ground | 470,000 |
| | 8 | Ground | 560 |
| XV3 | 1, 6 | Ground | 320 |

(2) *DOTTER.*

| Item | Measure from terminal | Measure to terminal | Voltage (volts) |
|---|---|---|---|
| Tube sockets: | | | |
| XV4 | 1 | Ground | 1 meg |
| | 2 | 3 | 33,000 |
| | 6 | Ground | 0 |
| | 7 | 8 | 1 meg |
| XV5 | 1, 6 | Ground | 33,000 |

*b. Typical Voltage Readings.* Voltages are measured with the equipment connected to its regular power supply, with tubes in place and all conditions normal.

(1) *LEVEL METER.*

| Item | Measure from terminal | Measure to terminal | Voltage (volts) |
|---|---|---|---|
| Tube sockets: | | | |
| XV1 | 1 | Ground | +130 dc |
| | 3 | Ground | +1.3 dc |
| | 4, 5 | 9 | 6.3 ac |
| | 6 | Ground | +130 dc |
| | 8 | Ground | +1.3 dc |
| XV2 | 1 | Ground | +130 dc |
| | 3 | Ground | +1.3 dc |
| | 4, 5 | 9 | 6.3 ac |
| | 6 | Ground | +160 dc |
| | 8 | Ground | +1.3 dc |
| XV3 | 1, 6 | Ground | 180 ac |
| | 3 | 4 | 6.3 ac |
| | 7 | Ground | +180 dc |

(2) *DOTTER.*

| Item | Measure from terminal | Measure to terminal | Voltage (volts) |
|---|---|---|---|
| Tube sockets: | | | |
| XV4 | 1 | Ground | −80 dc |
| | 8 | Ground | −115 dc |
| | 6 | Ground | 0 dc |
| | 4, 5 | 9 | 6.3 ac |
| XV5 | 1 | Ground | −30 dc |
| | 6 | Ground | −30 dc |
| | 8 | Ground | −80 dc |
| XV6, XV7 | 4, 5 | 9 | 6.3 ac |

## Section XX. TROUBLESHOOTING RECEIVER METER PANEL

### 328. Operational Test, RECEIVER METER PANEL

The operational test procedure for the LEVEL METER and LOOP CURRENT METER circuits of the RECEIVER METER PANEL is the same as the procedure described for the same circuits under the TRANSMITTER METER PANEL (par. 324). After these circuits have been tested and are operating properly, perform the operational test for the DELAY ADJUST METER. The operational test procedure for the DELAY ADJUST METER requires the use of a properly aligned transmitter and corresponding combiner and associated receivers. Channel 7 and 8 equipments of the AN/FGC–29 terminal are used for this purpose.

*a.* Arrange the test setup as follows:

(1) Set the switches of TRANSMITTER CHANNELS 7 and 8 to the following positions:

| Control | Setting |
|---|---|
| DIVERSITY switch | 4 CHANNEL LOOP 7 ONLY |
| IDLE-NORMAL switches | NORMAL |
| LOOP CURRENT SELECTOR switches. | 60MA |
| LOOP TERMINATION switches. | NEG |

(2) Connect the OUTPUT jack of the DOTTER on the TRANSMITTER METER PANEL to the LOOP 7 EQUIP jack on the transmitter. Set the Mark-SPACE-DOT switch on the transmitter METER PANEL to MARK. Connect the INPUT jack of the LOOP CURRENT METER to the METER jack of the DOTTER and adjust the current to 60 ma with the CHANNEL 7 LOOP CURRENT ADJUST control.

(3) Connect the CHANNEL 7 CHANNEL OUTPUT jacks of the transmitter to the ODD NO. CHAN. INPUT jacks of the DIVERSITY ALIGNMENT PANEL, and the CHANNEL 8 CHANNEL OUTPUT jacks to the EVEN NO. CHAN. INPUT jacks.

(4) Turn the COMMON ATTENUATOR switch on the DIVERSITY ALIGNMENT PANEL to 0.

(5) Connect the RECEIVER A ODD NUMBERED CHANNEL OUTPUT jacks of the DIVERSITY ALIGNMENT PANEL to the RECEIVER A EQUIP jacks of RECEIVER CHANNEL 7 and the RECEIVER A EVEN NUMBERED CHANNEL jacks to the RECEIVER A EQUIP jacks of RECEIVER CHANNEL 8.

(6) Set the four DELAY ADJ controls on the delay amplifiers in RECEIVER CHANNEL 7 and RECEIVER CHANNEL 8 to their extreme counterclockwise (0) positions.

(7) Set both RECEIVER A OUTPUT switches on the DIVERSITY ALIGNMENT PANEL to the ON position and both RECEIVER B OUTPUT switches to the OFF position.

(8) Set the combiner DIVERSITY switch to the 2-CHANNEL LOOPS, 7 and 8 and both IDLE-NORMAL switches to IDLE position. Set both LOOP CURRENT switches to the 20 MA position and both DISCRIMINATOR switches to NORMAL.

(9) Set the DELAY-BALANCE switch of the DELAY ADJUST METER in the BALANCE position, and the LOOP CURRENT switch to the ODD CHANNEL position.

(10) Connect the LOOP 7 EQUIP jack of the combiner to the ODD CHANNEL jack of the DELAY ADJUST METER and the LOOP 8 EQUIP jack to the EVEN CHANNEL jack.

(11) Insert open twin plugs into the RECEIVER B LINE jacks of RECEIVER CHANNEL 7 and RECEIVER CHANNEL 8.

*b.* Set the MARK-SPACE-DOT switch of the DOTTER to DOT and test the DELAY ADJUST METER as follows:

(1) Adjust the combiner CHANNEL 7 LOOP CURRENT ADJUST control to read exactly 20 ma on the LOOP CURRENT METER (30-ma scale) of the RECEIVER METER PANEL.

(2) Set the LOOP CURRENT switch of the DELAY ADJUST METER to the EVEN CHANNEL position, and adjust the CHANNEL 8 LOOP CURRENT ADJUST control of the combiner to read exactly 20 ma on the LOOP CURRENT METER. The DELAY ADJUST METER should now read 0 $\pm 2$ $\mu$a. Meter deflections to the right are considered positive, and to the left, negative.

(3) Depress the BALANCE SENSITIVITY switch and adjust the CHANNEL 8 LOOP CURRENT ADJUST control of the combiner to read $+40$ $\mu$a on the DELAY ADJUST METER. The meter should read $+4$ $\mu$a $\pm 1$ $\mu$a when the BALANCE SENSITIVITY switch is released.

(4) Depress the BALANCE SENSITIVITY switch and adjust the CHANNEL 8 LOOP CURRENT ADJUST control of the combiner to obtain a 0 reading on the DELAY ADJUST METER.

(5) Release the BALANCE SENSITIVITY switch and set the DELAY-BALANCE SWITCH to DELAY. Set the IDLE-NORMAL switches of COMBINER CHANNELS 7 and 8 to NORMAL. The DELAY ADJUST METER should read 0 $+4$ ma.

(6) Turn the RECEIVER A DELAY ADJ control of channel 7 fully clockwise. The DELAY ADJUST METER should read $+20$ $\mu$a $\pm 5$ $\mu$a.

(7) Turn the RECEIVER A DELAY ADJ control of channel 8 fully clockwise.

The DELAY ADJUST METER should read 0 ±4 μa.

(8) Return the RECEIVER A DELAY ADJ control of channel 7 to 0. The DELAY ADJUST METER should read −20 μa ±5 μa.

(9) Return the RECEIVER A DELAY ADJ control of channel 8 to 0. The DELAY ADJUST METER should read 0 ±4 μa.

*Note.* The readings given in (6) through (9) above are for a DOTTER speed of 30 cps. For a speed of 25 cps, the correct readings will be reduced about 15 percent.

## 329. RECEIVER METER PANEL, Troubleshooting Chart

(figs. 238–240)

The following chart is supplied as an aid in locating trouble in the RECEIVER METER PANEL. This chart lists the symptoms that can be observed and the probable cause of each symptom and gives the localization procedures to be used to correct it. After the trouble has been localized to a circuit in the LEVEL METER, the LOOP CURRENT METER, or the DELAY ADJUST METER in the RECEIVER METER PANEL, voltage and resistance measurements (par. 331) should be sufficient to locate the trouble. If the troubleshooting chart indicates the specific subassembly or circuit in which the trouble is likely to be found, trouble localization should begin with the test indicated by the paragraph reference in the *correction* column. Otherwise, the trouble localization procedures should begin with the first step given in paragraph 326*b* and *c* for the LEVEL METER and the LOOP CURRENT METER, respectively, and in paragraph 330*d* for the DELAY ADJUST METER. Procedures for the LEVEL METER and the LOOP CURRENT METER are given in paragraphs 326*b* and *c*, respectively, and for the DELAY ADJUST METER in paragraph 330.

| Symptom | Probable trouble | Correction |
|---|---|---|
| 1. LEVEL METER inoperative. | *a.* Failure of ac power supply | *a.* Check ac power source. Check power cord and connections. Check for 230 v ac between terminals 1 and 4 of transformer T3. Check fuses F1 and F2 and indicator lamps I 1 and I 2. |
| | *b.* Failure of B-plus voltage | *b.* Check for +165 v dc at terminal 2 of transformer T2. If absent, perform trouble localization tests on LEVEL METER (par. 326). |
| | *c.* Failure of heater voltage | *c.* Check for 6. 3 v ac between terminals 5 and 6 of transformer T3. If present, check heater circuit continuity. If absent, check transformer T3 (par. 331). |
| | *d.* Defective BRIDGING or TERMINATING jacks. | *d.* Check jacks J1 through J4. |
| | *e.* Defective transformer T1 | *e.* Check transformer T1 (par 331). |
| | *f.* Defective ATTENUATOR control AT1. | *f.* Check ATTENUATOR control AT1 (par.249). |
| | *g.* Failure of amplifier section of LEVEL METER. | *g.* Perform trouble localization on LEVEL METER circuit (par. 326*b*). |
| | *h.* Defective transformer T2 | *h.* Check transformer T2 (par. 331). |
| | *i.* Defective meter M1 | *i.* Check meter M1. |
| 2. LOOP CURRENT METER inoperative. | *a.* Defective INPUT jack | *a.* Check INPUT jack J5. |
| | *b.* Defective 90 MA-30 MA switch. | *b.* Check 90 MA-30 MA switch S3. |
| | *c.* Defective BIAS switch | *c.* Check BIAS switch S4. |
| | *d.* Failure of part or wiring in LOOP CURRENT METER circuit. | *d.* Perform trouble localization on the LOOP CURRENT METER circuit (par. 326*c*). |
| | *e.* Defective meter M2 | *e.* Check meter M2. |
| 3. DELAY ADJUST METER inoperative. | *a.* Defective ODD CHANNEL or EVEN CHANNEL input jack or defective INPUT jack in LOOP CURRENT METER. | *a.* Check jacks J5, J7, and J8. |

| Symptom | Probable trouble | Correction |
|---|---|---|
| 3. DELAY ADJUST METER inoperative. | *b.* Defective LOOP CURRENT switch. | *b.* Check LOOP CURRENT switch S5. |
| | *c.* Failure of part or wiring in DELAY ADJUST METER circuit. | *c.* Check the DELAY ADJUST METER circuit (par. 330*d*). |
| | *d.* Defective DELAY-BALANCE switch. | *d.* Check DELAY-BALANCE switch S7. |
| | *e.* Defective meter M3_____ | *e.* Check meter M3. |
| 4. LEVEL METER out of limits. | *a.* LEVEL METER out of calibration. | *a.* Adjust resistor R21. Refer to calibration procedure for LEVEL METER (par. 85*a*). |
| | *b.* Failure of wiring or part in LEVEL METER. | *b.* Perform trouble localization for LEVEL METER (par. 326*b*). |
| 5. LOOP CURRENT METER out of limits. | Failure of wiring or part in LOOP CURRENT METER circuit. | Perform trouble localization tests for LOOP CURRENT METER (par. 326*c*). |
| 6. DELAY ADJUST METER out of limits. | Failure of wiring or part in DELAY ADJUST METER circuit. | Perform trouble localization tests for DELAY ADJUST METER (par. 330*d*). |

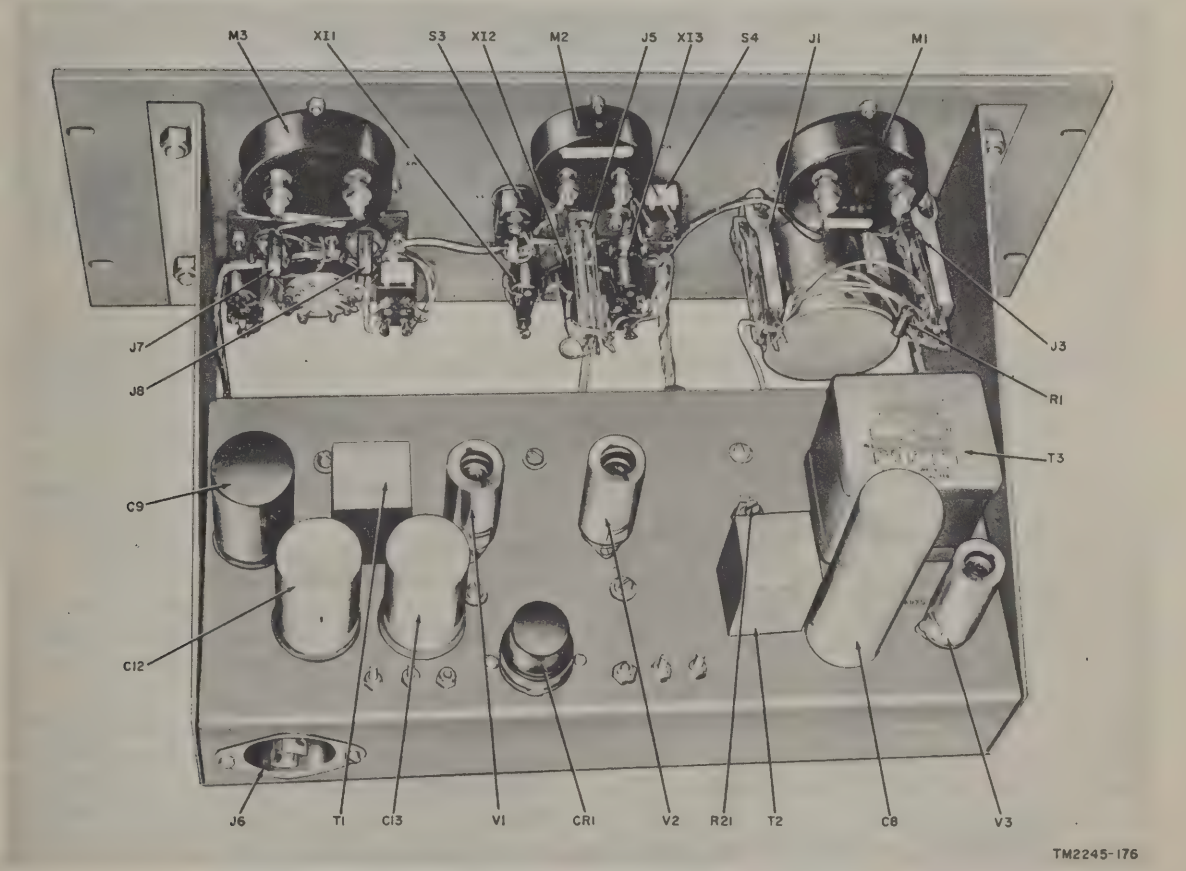



*Figure 238. RECEIVER METER PANEL, top view.*

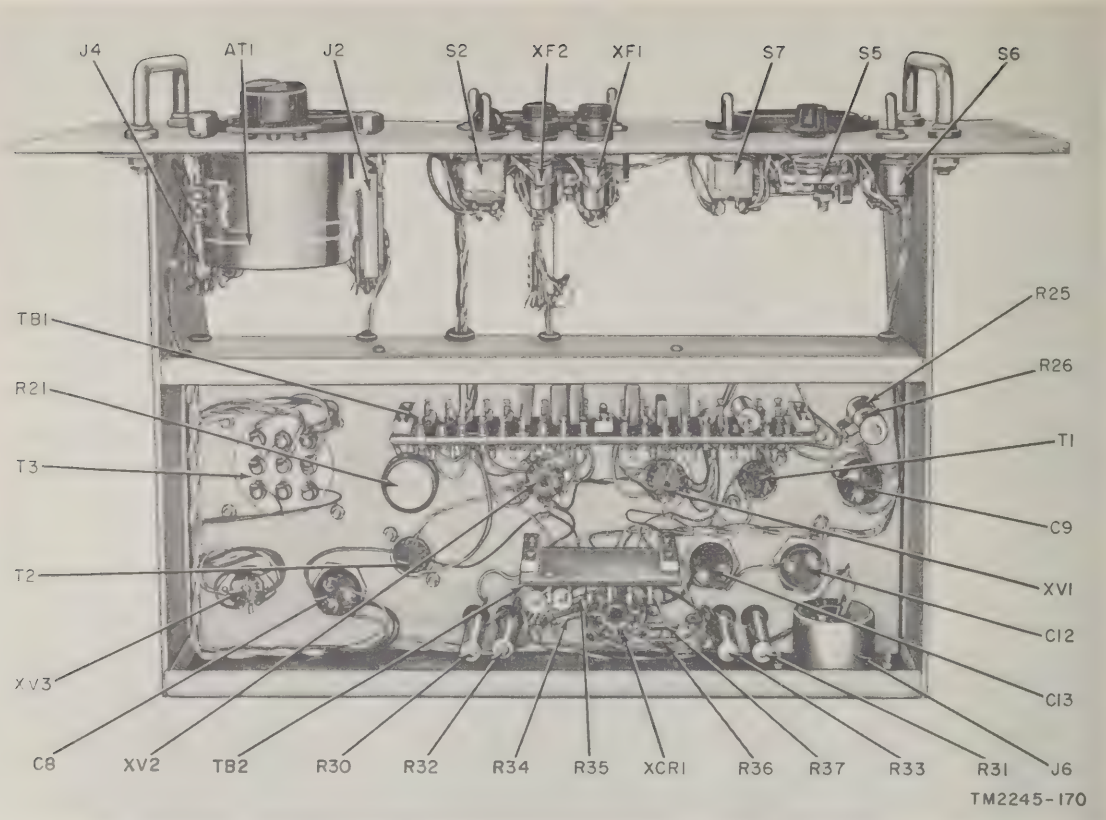



*Figure 239. RECEIVER METER PANEL, bottom view.*

## 330. Trouble Localization, RECEIVER METER PANEL

(figs. 238–240).

The general procedure for localizing trouble is described in paragraph 239*c*. To trace trouble in the RECEIVER METER PANEL, test the LEVEL METER, the LOOP CURRENT METER, and the DELAY ADJUST METER. Trace the circuit under test on the RECEIVER METER PANEL schematic diagram (fig. 155). To check the actual wiring, refer to the RECEIVER METER PANEL wiring diagram (fig. 296).

***Caution:*** In the following tests, do not check meter M1, M2 or M3 with the ohmmeter. The current from the ohmmeter may damage the meters. Replace a suspected meter with a similar meter known to be good. If this clears the trouble, the meter is defective and should be replaced.

*a. Test Setup.* Remove the RECEIVER METER PANEL from cabinet 5 (par. 245*b*). Place the unit on a suitable table at the rear of cabinet 5 so that cabinet plug P123 may be connected to connector J6.

*b. Localization Tests, LEVEL METER.* The trouble localization tests for the LEVEL METER in the RECEIVER METER PANEL are the same as the tests for the identical unit in the TRANSMITTER METER PANEL (par. 326*b*).

*c. Localization Tests, LOOP CURRENT METER.* The trouble localization tests for the LOOP CURRENT METER on the RECEIVER METER PANEL are the same as for the identical unit on the TRANSMITTER METER PANEL (par. 326*c*).

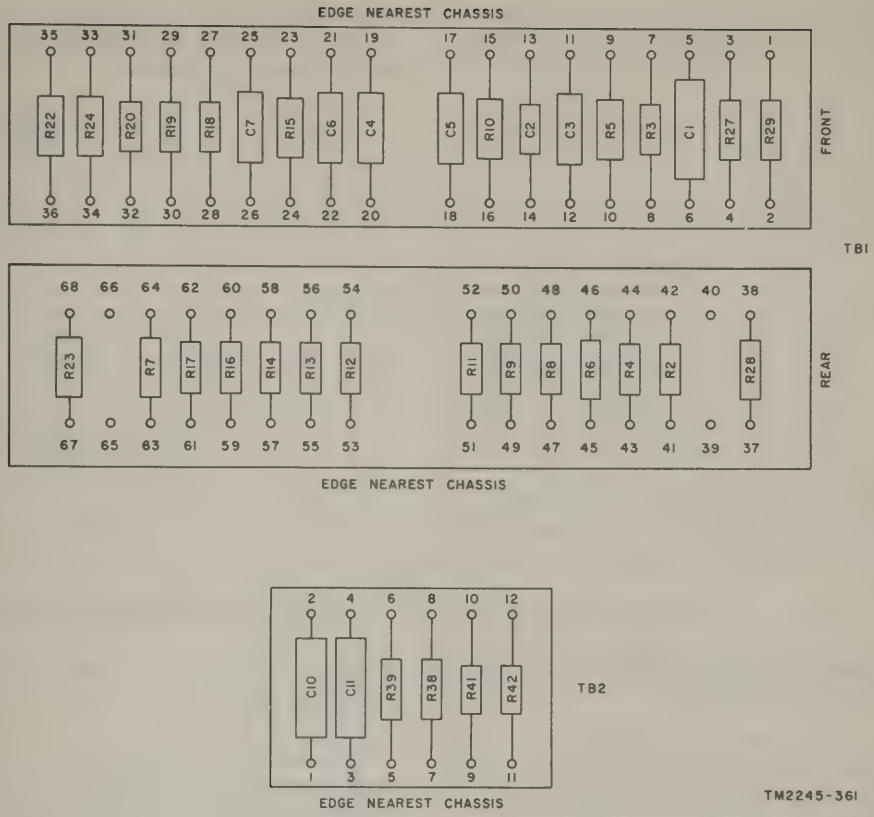



*Figure 240. RECEIVER METER PANEL, terminal boards TB1 and TB2.*

*d. Localization Tests, DELAY ADJUST METER.* To localize trouble in the DELAY ADJUST METER, proceed as follows:

(1) Insert a plug into the INPUT jack of the LOOP CURRENT METER to disconnect it from the DELAY ADJUST METER circuit.
(2) See that no plugs are inserted in either the EVEN CHANNEL or ODD CHANNEL jacks J7 or J8.
(3) Remove varistor CR1 and set the DELAY-BALANCE switch to DELAY.
(4) Check resistor R40.
(5) Set the DELAY-BALANCE switch to BALANCE.
(6) Check resistors R30 through R39 and resistors R41 and R42.
(7) Check capacitors C10 and C11.
(8) Check switch S5 and varistor CR1.

## 331. Additional Troubleshooting Information, RECEIVER METER PANEL

*a. Typical Resistance Readings.* The resistances of transformers are measured with all connections removed from their terminals. The resistance at the terminals of the tube sockets are measured with all connections intact and all conditions normal except that the power is disconnected from the component. Typical resistance measurements for the RECEIVER METER PANEL are given in the chart below.

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Transformers: | | | |
| T1 | 1 | 2 | 180 |
| | 3 | 4 | 180 |
| T2 | 1 | 2 | 180 |
| | 3 | 4 | 60 |

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Transformers: | | | |
| T3 | 1 | 4 | 160 |
| | 5 | 6 | .45 |
| | 7 | 8 | 160 |
| | 8 | 9 | 150 |
| Tube sockets: | | | |
| XV1 | 3 | Ground | 1,000 |
| | 7 | Ground | 470,000 |
| | 8 | Ground | 1,000 |
| XV2 | 2 | Ground | 470,000 |
| | 3 | Ground | 1,000 |
| | 7 | Ground | 470,000 |
| | 8 | Ground | 560 |
| XV3 | 1, 6 | Ground | 320 |

*b. Typical Voltage Readings.* Voltages are measured with the equipment connected to its regular power supply with tubes in place and all conditions normal. Typical voltage measurements for the RECEIVER METER PANEL are given in the chart below.

| Item | Measure from terminal | Measure to terminal | Voltage (volts) |
|---|---|---|---|
| Tube sockets: | | | |
| XV1 | 1 | Ground | +130 dc |
| | 3 | Ground | +1.35 dc |
| | 4, 5 | 9 | 6.3 ac |
| | 6 | Ground | +130 dc |
| | 8 | Ground | +1.35 dc |
| XV2 | 1 | Ground | +130 dc |
| | 3 | Ground | +1.2 dc |
| | 4, 5 | 9 | 6.3 ac |
| | 6 | Ground | +160 dc |
| | 8 | Ground | +1.3 dc |
| XV3 | 1, 6 | Ground | +180 dc |
| | 3 | 4 | 6.3 ac |
| | 7 | Ground | +180 dc |

## Section XXI. TROUBLESHOOTING DIVERSITY ALIGNMENT PANEL

### 332. Operational Test, DIVERSITY ALIGNMENT PANEL

The general procedure for making an operational test is given in paragraph 239*b*. The DIVERSITY ALIGNMENT PANEL is tested in place and connected to its normal power supply as installed. Proceed as follows:

*a.* Set the POWER switch to ON, the COMMON ATTENUATOR switch to 0, and all OUTPUT OFF-ON switches to OFF.

*b.* Connect the OUTPUT jacks of Signal Generator SG–15/PCM to the ODD NO. CHAN. INPUT jacks on the DIVERSITY ALIGNMENT PANEL.

*c.* Set the signal generator frequency to 2,000 cps at a level of −15 dbm.

*d.* Connect the TERMINATING jacks of the LEVEL METER in the RECEIVER METER PANEL to the four OUTPUT jack pairs of the DIVERSITY ALIGNMENT PANEL, one pair at a time. Turn the appropriate OUTPUT OFF-ON switch momentarily to the ON position to obtain a reading. The reading at each jack pair should be −8 dbm ±1 db.

*e.* Set the COMMON ATTENUATOR switch to 40, and increase the signal generator level to +5 dbm. The reading at each OUTPUT jack pair should be −28 dbm ±1 db.

*f.* Connect the signal generator to the EVEN NO. CHAN. INPUT jacks. The reading at each OUTPUT jack pair should be −28 dbm ±1 db.

*g.* Connect the OUTPUT jacks of the signal generator to the IN jacks of the BRANCHING NETWORK. Keep the signal generator output level at +5 dbm.

*h.* Connect the TERMINATING jacks of the LEVEL METER in the TRANSMITTER METER PANEL to the OUT 1 jacks of the BRANCHING NETWORK and the TERMINATING jacks of the LEVEL METER in the RECEIVER METER PANEL to the OUT 2 jacks. Both LEVEL METERS should read −1 dbm ±.5 db.

### 333. DIVERSITY ALIGNMENT PANEL, Troubleshooting Chart

(fig. 241–243)

The following chart is supplied as an aid in locating trouble in the DIVERSITY ALIGNMENT PANEL. This chart lists the symptoms that can be observed, the probable cause of a symptom, and gives the localization procedures to be used to correct it. After the trouble has been localized to a circuit in the DIVERSITY ALIGNMENT PANEL, trouble localization tests (par. 334) or voltage and resistance measurements (par. 335) should be sufficient to locate the trouble. If the troubleshooting chart indicates the specific

circuit in which the trouble is likely to be found, trouble localization should begin with the test indicated by the paragraph reference in the *correction* column. Otherwise, the trouble localization procedures should begin with the first step given in paragraph 334.

| Symptom | Probable trouble | Correction |
|---|---|---|
| 1. No output signal from OUTPUT receiver jack pairs. | *a.* Failure of ac power source. | *a.* Check ac power source. Check power cord and connector. Check for 115 v ac between terminals 2 and 4 of transformer T3. Check fuses F1 and F2 and indicator lamps I 1 and I 2. Check switch S6. |
| | *b.* Failure of heater voltage. | *b.* Check for 6.3 v ac between terminals 5 and 6 of transformer T3. If present, check heater circuit continuity. If absent, check transformer T3 (par. 335). |
| | *c.* Failure of B-plus voltage. | *c.* Check for +180 v dc at terminal 4 of transformer T2. If absent, perform trouble localization tests on power supply section of DIVERSITY ALIGNMENT PANEL (par. 334*c*). |
| | *d.* Failure of ODD NO. CHAN. or EVEN NO. CHAN. jacks. | *d.* Check jacks J1 through J4. |
| | *e.* Failure of COMMON ATTENUATOR switch or pads. | *e.* Check switch S1 and pads AT1, AT2, and AT3. |
| | *f.* Failure of transformer T1. | *f.* Check transformer T1 (par. 335). |
| | *g.* Failure of amplifier section of DIVERSITY ALIGNMENT PANEL. | *g* Perform trouble localization on amplifier section of DIVERSITY ALIGNMENT PANEL (par. 334*b*). |
| | *h.* Failure of transformer T2. | *h.* Check transformer T2 (par. 335). |
| 2. Output signals from DIVERSITY ALIGNMENT PANEL out of limits. | *a.* Defective pads. | *a.* Check pads AT1, AT2, and AT3. |
| | *b.* Defective amplifier section. | *b.* Perform trouble localization on amplifier section of DIVERSITY ALIGNMENT PANEL (par. 334*b*). |
| 3. ODD NUMBERED CHANNEL RECEIVER A path inoperative. | *a.* Defective switch or OUTPUT jacks. | *a.* Check switch S2 and jacks J5 and J6. |
| 4. ODD NUMBERED CHANNEL RECEIVER B path inoperative. | *a.* Defective switch or OUTPUT jacks. | *a.* Check switch S3 and jacks J7 and J8. |
| 5. EVEN NUMBERED CHANNEL RECEIVER A path inoperative. | *a.* Defective switch or OUTPUT jacks. | *a.* Check switch S4 and jacks J9 and J10. |
| 6. EVEN NUMBERED CHANNEL RECEIVER B path inoperative. | *a.* Defective switch or OUTPUT jacks. | *a.* Check switch S5 and jacks J11 and J12. |
| 7. No output signal from BRANCHING NETWORK. | *a.* Defective jack or resistors R25 and R28. | *a.* Check jacks J14 and J15 and resistors R25 and R28. |
| 8. No output signal from OUT 1 path of BRANCHING NETWORK. | *a.* Defective jacks or resistors. | *a.* Check jacks J16 and J17 and resistors R26 and R30. |
| 9. No output signal from OUT 2 path of BRANCHING NETWORK. | *a.* Defective jacks or resistors. | *a.* Check jacks J18 and J19 and resistors R27 and R29. |

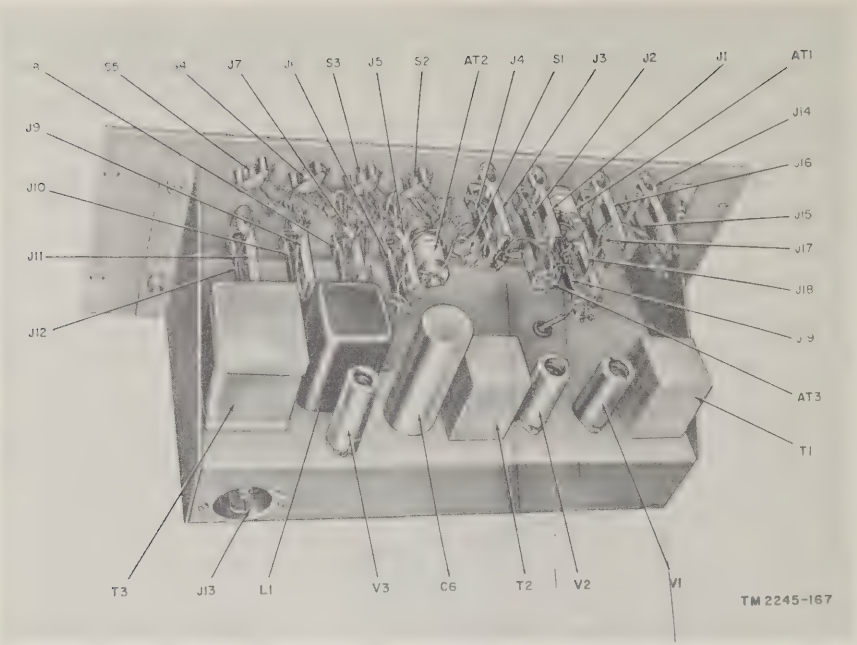



*Figure 241. DIVERSITY ALIGNMENT PANEL, top view.*

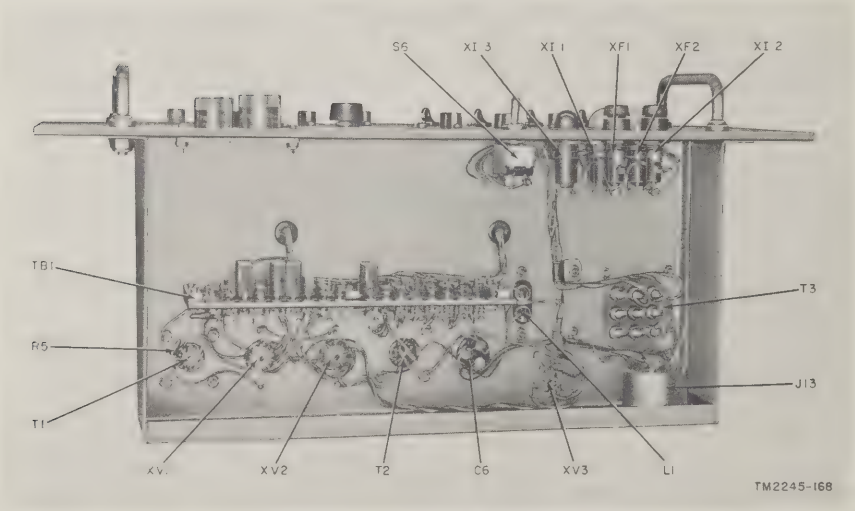



*Figure 242. DIVERSITY ALIGNMENT PANEL, bottom view.*

## 334. Trouble Localization, DIVERSITY ALIGNMENT PANEL

(figs. 161 and 297)

The general procedure for localizing trouble is described in paragraph 239*c*. To trace trouble in the DIVERSITY ALIGNMENT PANEL, test the power supply section, the amplifier section, and the BRANCHING NETWORK. Use Signal Generator SG–15/PCM, Electronic Multimeter ME–6A/U, and the LEVEL METERS of the TRANSMITTER METER PANEL and RECEIVER METER PANEL for the tests. Trace the circuit under test on the DIVERSITY ALIGNMENT PANEL schematic diagram (fig. 161). To check the actual wiring, refer to the

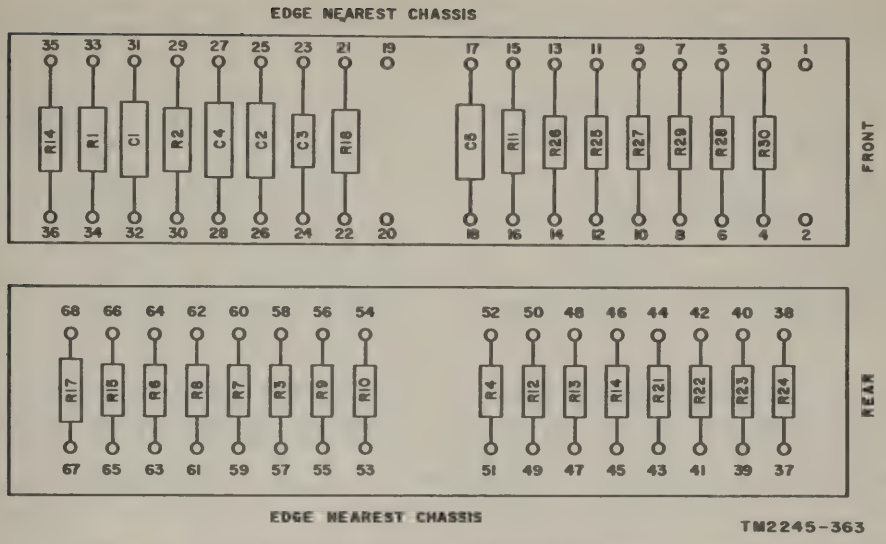



*Figure 243. DIVERSITY ALIGNMENT PANEL, terminal board TB1.*

DIVERSITY ALIGNMENT PANEL wiring diagram (fig. 297).

*a. Test Setup.* Remove the DIVERSITY ALIGNMENT PANEL from cabinet 3 (par. 245*b*). Place the unit on a suitable table at the rear of cabinet 3 so that cabinet plug P123 may be connected to connector J13 and the underside of the chassis can be reached.

*b. Localization Tests, Amplifier Section.*

(1) Adjust the frequency of the signal generator to 2,000 cps and the level to +5 dbm.

(2) Connect the OUTPUT jacks of the signal generator to the ODD NO. CHAN. INPUT jacks of the DIVERSITY ALIGNMENT PANEL.

(3) Set the COMMON ATTENUATOR switch to the 40 position and the POWER switch of the DIVERSITY ALIGNMENT PANEL to the ON position. Allow a few minutes for the equipment to warm up.

(4) Connect the LEVEL METER of the RECEIVER METER PANEL to the OUTPUT jacks one pair at a time, momentarily setting the corresponding ON-OFF switch to ON. The LEVEL METER should read −28 dbm in each case. If it is not possible to obtain these readings, proceed with the localization measurements listed in the table below.

| Test No. | Electronic Multimeter ME-6A/U probe connections | Normal reading (volts) | Corrective measures |
|---|---|---|---|
| 1 | Attenuator AT1, terminal IN and ground | 1.4 | Check jacks J1 and J2, switch S1 and attenuator AT1. |
| 2 | Attenuator AT2, terminal IN and ground | .14 | Check attenuators AT1 and AT2. Check switch S1. |
| 3 | Attenuator AT3, terminal IN and ground | .014 | Check attenuators AT2 and AT3. Check switch S1. |
| 4 | Transformer T1, terminal 1 and 2 (ground). | .0055 | Check attenuator AT3 and transformer T1 (par. 335). |
| 5 | Tube socket XV1, terminal 2 and ground | .0034 | Check transformer T1 (par. 335). Check tube V1. Measure dc voltages and resistances at tube socket XV1 (par. 335). Check resistors R5, R14, and R17. Check capacitor C5. |
| 6 | Tube socket XV1, terminal 7 and ground | .035 | Check tube V1. Measure dc voltages and resistances at tube socket XV1 (par. 335). Check resistors R1 and R6 and capacitor C1. |

| Test No. | Electronic Multimeter ME-6A/U probe connections | Normal reading (volts) | Corrective measures |
|---|---|---|---|
| 7 | Tube socket XV2, terminal 2 and ground | . 27 | Check tubes V1 and V2. Measure dc voltages and resistances at tube sockets XV1 and XV2 (par. 335). Check resistors R2, R3, R7, R8 and R9. Check capacitors C2, C3, and C4. |
| 8 | Transformer T2, terminals 6 and 5 (ground) (all OUTPUT switches on OFF). | . 05 | Check tube V2. Measure dc voltages and resistance at tube socket XV2 (par. 335). Check transformer T2 (par. 335) and resistor R11. |
| 9 | OUTPUT jacks (energize appropriate jack by associated OUTPUT switch). | . 031 | Check resistors R4, R12, R13, R16 and resistors R21 through R24. Check switches S2 through S5 and jacks J5 through J12. |

*c. Localization Tests, Power Supply Section.* Make the tests outlined in the following table to locate trouble in the power supply section of the DIVERSITY ALIGNMENT PANEL.

| Test No. | Multimeter TS-352/U probe connections | Normal reading (volts) | Corrective measures |
|---|---|---|---|
| 1 | Transformer T3, terminals 7 and 9 | 180 ac | Check connector J13 and switch S6. Check fuses F1 and F2 and indicators I 1 and I 2. Check transformer T3 (par. 335*a*). |
| 2 | Transformer T3, terminals 5 and 6 | 6.3 ac | Check transformer T3 (par. 335*a*). |
| 3 | Inductor L1, terminal 2 and ground | +180 dc | Check tube V3 and inductor L1 (par. 335*a*). Check capacitor C6 and resistor R18. |

*d. Localization Tests, Branching Network.* To localize trouble in the branching network, proceed as follows:

(1) Measure the values of resistors R25 through R30. Replace any defective resistor.

(2) Check jacks J14 through J19 and the continuity of the wiring between jacks and resistors.

## 335. Additional Troubleshooting Information, DIVERSITY ALIGNMENT PANEL

*a. Typical Resistance Readings.* The resistances of transformers are measured with all connections removed from their terminals. The resistance at the terminals of the tube sockets are measured with all conditions intact and all conditions normal except that power is disconnected from the component. Typical resistance measurements for the DIVERSITY ALIGNMENT PANEL are given in the chart below.

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Transformers: | | | |
| T1 | 1 | 2 | 28 |
| | 3 | 4 | 130 |
| T2 | 1 | 2 | 89 |
| | 3 | 4 | 89 |
| | 5 | 6 | 36 |
| T3 | 1 | 3 | 80 |
| | 2 | 4 | 80 |
| | 5 | 6 | . 45 |
| | 7 | 8 | 160 |
| | 8 | 9 | 150 |
| Inductor L1 | 1 | 2 | 230 |
| Tube sockets: | | | |
| XV1 | 2 | Ground | 4, 900 |
| | 3 | Ground | 1, 200 |
| | 7 | Ground | 470, 000 |
| | 8 | Ground | 1, 200 |
| XV2 | 2, 7 | Ground | 470, 000 |
| | 3, 8 | Ground | 680 |
| XV3 | 1, 6 | Ground | 310 |

*b. Typical Voltage Readings.* Voltages are measured with the equipment connected to its regular power supply with tubes in place and all conditions normal. Typical voltage measurements are given in the chart below.

| Item | Measure from terminal | Measure to terminal | Voltage (volts) |
|---|---|---|---|
| Tube sockets: | | | |
| XV1 | 1 | Ground | +150 dc |
| | 3 | Ground | +1.4 dc |
| | 4, 5 | 9 | 6.3 ac |
| | 6 | Ground | +150 dc |
| | 8 | Ground | +1.4 dc |
| Tube sockets: | | | |
| XV2 | 1, 6 | Ground | +180 dc |
| | 3, 8 | Ground | +6.6 dc |
| | 4, 5 | 9 | 6.3 ac |
| XV3 | 1, 6 | Ground | 180 ac |
| | 3 | 4 | 6.3 ac |
| | 7 | Ground | +180 dc |
| Transformer T3 | 5 | 6 | 6.3 ac |
| Inductor L1 | 2 | Ground | +180 dc |

## Section XXII. MISCELLANEOUS TROUBLE-SHOOTING PROCEDURES

### 336. Operational Test, Main Power Unit (fig. 35)

The general procedure for performing an operational test is given in paragraph 239*b*. Refer to the ac power distribution schematic diagrams (figs. 260 and 261).

*a. Test Setup.* The main power unit remains in place and wired as installed. To reach the input and output connections, remove the four cover screws and lift off the top cover. Use Multimeter TS–352/U for the tests described in *b* below.

*b. Test Procedure.* With the main power unit connected to its normal source of power, proceed as follows:

(1) Connect the multimeter (250-volt ac range) across the two upper terminals of ON-OFF switch S1. The multimeter should read 115 volts ac ±10 percent or 230 volts ac ±10 percent, depending on the primary power source.

(2) Connect the multimeter between the sleeve terminals of fuse holders XF4 and XF5. The multimeter should read 115 volts ac ±5 percent.

(3) Connect the multimeter between the sleeve terminals of fuse holders XF3 and XF5. The multimeter should read 230 volts ac ±5 percent.

(4) Disconnect the multimeter from the fuse holders and replace the top cover.

### 337. Additional Troubleshooting Information, Main Power Unit

The resistances of the transformer in the main power unit are measured with all connections removed from its terminals. Typical resistance measurements are given in the chart below.

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Transformer T1 | 1 | 7 | .31 |

### 338. Troubleshooting Information, Step-Up Power Transformer

Measure the resistances of the step-up power transformer (cabinet 5) with all connections removed from its terminals. Typical resistance measurements are given in the chart below.

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Transformer T1 | 1 | 2 | .25 |
| | 3 | 4 | .85 |

### 339. Troubleshooting Procedure, Power Panel (fig. 244)

To locate trouble in the power panel (cabinets 1 through 6), proceed as follows:

*a.* Check BLOWER MOTOR fuses F1 and F2. The BLOWER MOTOR BLOWN FUSE INDICATORS associated with these fuses are located on the front cover panel.

*b.* If fuses F1 and F2 are removed and BLOWER MOTOR BLOWN FUSE INDICATORS fail to light, check connector J136, mating plug P136, and the wiring from the power panel to the front cover panel. Check resistors R1 and R2.

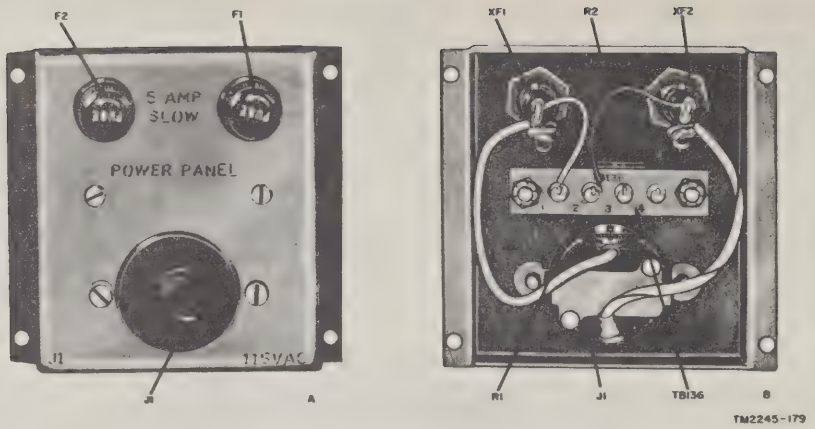



*Figure 244. Power panel, front and rear views.*

*c.* Measure the resistance between the contacts of plug P1 of the blower motor power cord. The resistance should be 5.3 ohms.

## 340. Troubleshooting Procedure, DUMMY CIRCUIT PANEL

(fig. 245)

Troubleshooting procedure for the DUMMY CIRCUIT PANEL consist of continuity tests of the internal wiring on connector J2. Test the wiring between the terminals shown in the following table.

| Connector J2 | |
|---|---|
| From terminal | To terminal |
| A | E |
| B | F |
| C | G |
| D | H |

## 341. Operational Test, RELAY PANEL

(figs. 10, 246, and 247)

The general procedure for performing an operational test is described in paragraph 239*b*. Refer to figure 151 for the RELAY PANEL schematic diagram and to figure 298 for the wiring diagram.

*a. Test Setup.* The RELAY PANEL is not mounted in the AN/FGC–29 terminal but is located elsewhere in the communications center. The RELAY PANEL may remain in its installed location for test. Use Multimeter TS–352/U.

*b. Power Supply Circuit Test.* The power supply circuit provides direct current for biasing the windings of all 16 relays. Each relay receives a spacing bias current of 30 ma. To determine if the power supply circuit is functioning properly, check the input and output voltages, as follows:

(1) Loosen the three screws at the top of the rear hinged panel on the RELAY PANEL and open it (fig. 247).[1] By allowing this panel to hang downward, the wiring of the power circuit can be reached.

(2) Arrange Multimeter TS–352/U to read ac volts on the 250-volt scale and connect it between terminals 1 and 3 of transformer T1. The multimeter should read 115 volts ac.

(3) Connect the multimeter between terminals 2 and 4 of transformer T1. The multimeter should read 115 volts ac.

(4) Arrange the multimeter to read dc volts on the 50-volt scale. Connect the multimeter between the + and — terminals of capacitor C17. The multimeter should read 25 volts ±2 volts.

(5) To check the bias winding of any one relay circuit set, the multimeter on the 10-volt dc scale and connect it between terminal 2 on the relay socket and the negative terminal of capacitor C17. The multimeter should read 4.8 volts.

(6) Close the rear hinged panel and replace the three screws that support it.

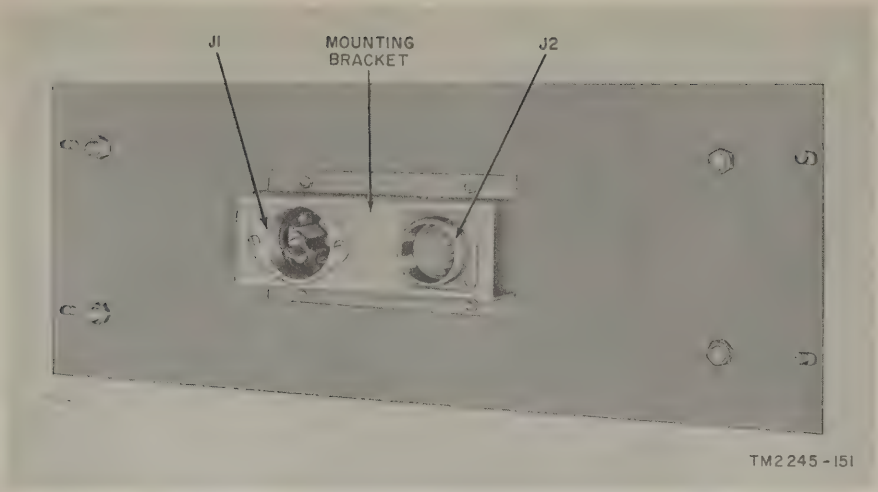



*Figure 245. DUMMY CIRCUIT PANEL, rear view.*

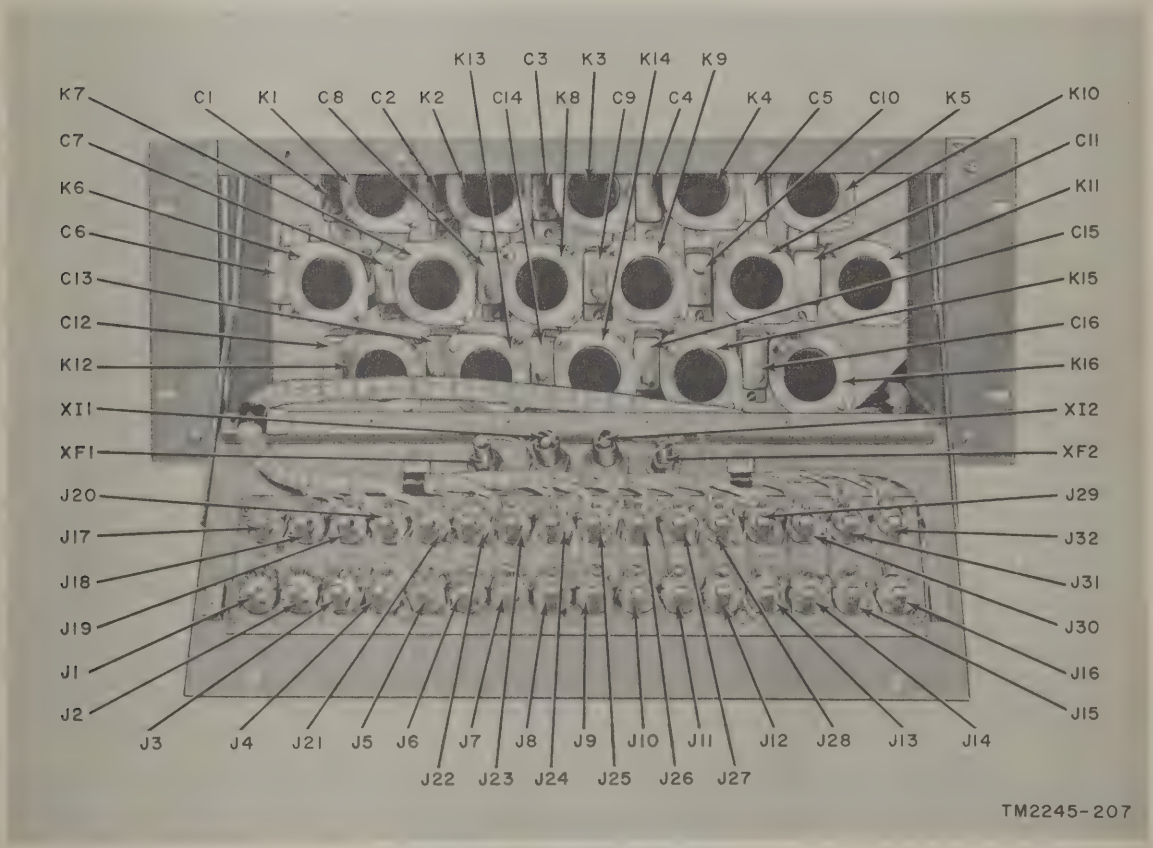



*Figure 246. Relay panel, front view*

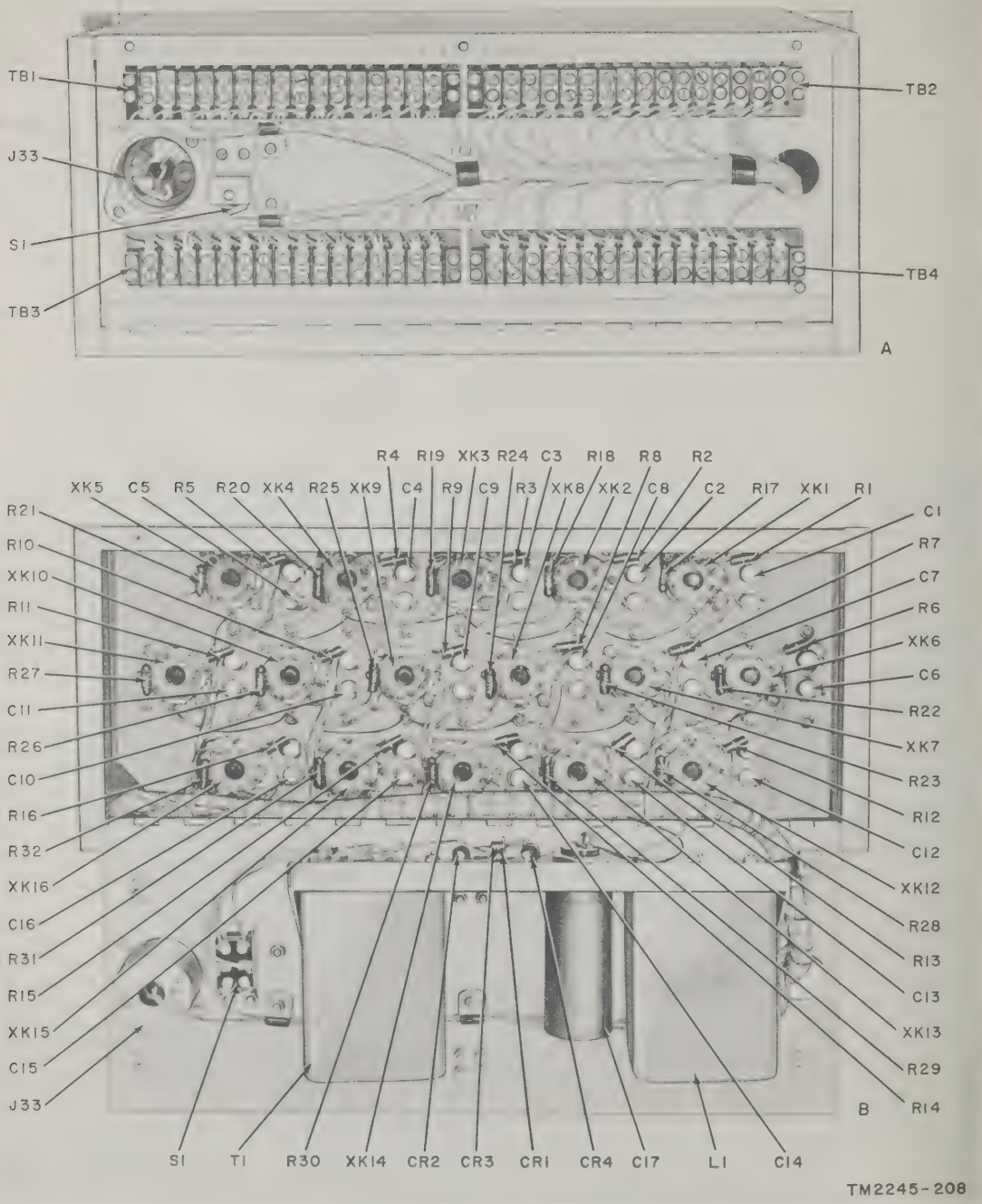



*Figure 247. Relay panel, rear views.*

*c. Operating Winding and Contacts Test.* The operating windings and contacts of the 16 relay circuits are separate and independent of each other. When trouble occurs it will generally be known which of these 16 relay circuits is affected. Check only the particular circuit as follows:

(1) Tag and disconnect the four external wires associated with the relay circuit under test at the terminal board on the rear of the RELAY PANEL (fig. 151).

(2) Arrange the multimeter to measure resistance and connect it across the driven loop output terminals for the particular relay circuit (fig. 151). The meter should indicate an open circuit.

(3) Energize the operating winding by applying a 60-ma direct current to the driving loop input terminals for the particular relay circuit (fig. 151). Observe the proper polarity; current enters the RELAY PANEL at the even-numbered terminal and leaves at the odd-numbered terminal. The multimeter should indicate a short circuit.

(4) Insert an open plug into the CONTACT monitor jack for the particular relay circuit (fig. 151). The multimeter should indicate an open circuit.

(5) Remove the plug from the CONTACT monitor jack and insert it into the CORD monitor jack. The multimeter should indicate an open circuit.

(6) Remove the open plug and disconnect the multimeter from the RELAY PANEL. Connect the external wires that were removed as instructed in (1) above.

## 342. Additional Troubleshooting Information, RELAY PANEL

The resistance measurements for any relay circuit on the RELAY PANEL are performed with the RELAY PANEL in place, but with the power disconnected. Also remove the external connections from the terminals associated with the relay circuit under test (fig. 151) and with the particular relay removed from its socket. Typical resistance measurements are given in the chart below. Transformers and inductors are measured with all connections removed.

| Item | Measure from terminal | Measure to terminal | Resistance (ohms) |
|---|---|---|---|
| Relay K1 through K16 | 1 | 8 | 160 |
| | 2 | 3 | 160 |
| Relay socket XK1 through XK16. | 2 | Ground | 680 |
| Transformer T1 | 1 | 3 | 40 |
| | 2 | 4 | 40 |
| | 5 | 6 | 2.5 |
| Inductor L1 | 1 | 2 | 10 |

# Section XXIII. REPAIRS

## 343. Removal and Replacement of Parts

Most of the parts of the AN/FGC–29 terminal can be reached and replaced if found to be defective. For parts that are not easily reached, follow the procedures in paragraph 245. Follow the precautions listed in paragraph 244 when removing or repairing any subassembly or part. Minor repairs can be made on the top or bottom of a drawer-type component without removing it from the cabinet by drawing the unit out of the cabinet. For extensive repairs, the equipment may have to be removed from the cabinet.

*a. Removal of Equipment.* Follow the procedure in paragraph 58 to remove a drawer-mounted component. To remove panel-mounted components, loop battery supplies, and voltage regulators, follow the procedures in paragraph 245.

*b. Removal of Subassemblies.* To remove a subassembly for repair, first disconnect all the external wiring brought into the terminal board associated with its external connections; tag each wire. Then unfasten the bolts that hold the subassembly to the chassis. The terminal board connections are reached from the bottom of the chassis and the mounting bolts from the top. Carefully lift the subassembly out of position; be careful not to damage any wiring or parts that may be close to it.

*c. Replacement of Parts.* To replace parts mounted on or below terminal boards or internal wiring in many cases, the terminal board has to be removed to reach the particular part or wiring. Unscrew the mounting bolts that fasten the terminal board in place. The individual connections

to the wiring harness are made long enough to permit lifting the terminal board a short distance from its mounting position. Move the terminal board only far enough to reach parts or wiring to be removed or replaced.

*d. Removal of Pluck-out Parts.* For instructions covering the removal of pluck-out parts (tubes, crystals, varistors, fuses and lamps), refer to paragraph 243.

### 344. Adjustments

All troubleshooting on the AN/FGC–29 terminal is done with the component located in the terminal and powered by its normal supply. Components that require adjustment following repair are therefore adjusted as part of the final test procedure (par. 348) with the component installed in its normal location in the AN/FGC–29 terminal.

### 345. Refinishing

Instructions for refinishing badly marred panels are given in TM 9–2851, Painting Instructions for Field Use. For rustproofing and painting instructions, refer to paragraph 237.

## Section XXIV. FINAL TESTS

### 346. General

This section is to be used as a guide in determining the quality of a repaired component of the AN/FGC–29 terminal. In addition to the test equipment built into the AN/FGC–29 terminal, the equipment listed in paragraph 241 is required. The tests to be performed are described in paragraph 348.

### 347. Precautions, Final Testing

When making the final tests, observe the following precautions to be sure the equipment will function properly.

*a.* When making final tests of components in the telegraph transmitter group or telegraph receiver group, it is usually necessary to terminate the transmitting and receiving telegraph loops in ground.

*b.* Set the LEVEL ADJUST control of the LEVEL CONTROL & PLATE SUPPLY (fig. 49) and the DELAY ADJ controls of the receivers (fig. 54) to their normal settings.

*c.* Do not disturb any uncalibrated screwdriver-adjustable controls.

*d.* Set the front panel and internal switches of transmitters and combiners as required by the particular transmitting or receiving loop circuit involved before returning the equipment to service.

*e.* Set the front panel switches of the LEVEL CONTROL & PLATE SUPPLY as indicated in paragraph 83*h* and the switches of the LOOP BATTERY PANELS as indicated in paragraph 83*g* before returning the equipment to service.

*f.* When calibrating the LEVEL METER (par. 85*a*) on the TRANSMITTER METER PANEL or RECEIVER METER PANEL, use a Signal Generator SG–15/PCM which is known to be accurate. Similarly, when checking a LOOP CURRENT METER (par. 85*b*) use an accurately calibrated Multimeter TS–352/U.

*g.* To remove a blower or blower motor from a cabinet, shut off power to the cabinet to prevent overheating the equipment.

*h.* When other than minor repairs are made, check the line-up of the system following the final testing. Check that portion of the system line-up that could be affected by the repaired equipment. Follow the applicable procedures in paragraphs 107 through 111.

### 348. Final Test Procedures

After a component of the AN/FGC–29 terminal has been repaired, it must be lined-up and tested in place to determine that it is fit for return to service. The final tests for the various components of the AN/FGC–29 terminal are the same as the equipment line-up for the component involved.

*a.* Final tests for the TRANSMITTER METER PANEL are described in paragraph 85, for the RECEIVER METER PANEL in paragraphs 86 and 103, and for the DIVERSITY ALIGNMENT PANEL in paragraphs 87 and 103.

*b.* Final tests for TRANSMITTER CHANNELS 1 and 2 through TRANSMITTER CHANNELS 15 and 16 are described in paragraphs 88 and 96*a*. Be sure both transmitting loops for the transmitter involved are terminated in ground before performing the tests.

*c.* Final tests for the SUBGROUP MODULATOR and for the LEVEL CONTROL &

PLATE SUPPLY are described in paragraphs 89 and 90, respectively, and in paragraph 96*b* for both components.

*d*. Final tests for SUBGROUP DEMODULATOR A or B are described in paragraphs 92 and 102.

*e*. Final tests for RECEIVER CHANNEL 1 through RECEIVER CHANNEL 16 are described in paragraphs 93, 99, and 101.

*f*. Final tests for COMBINER CHANNELS 1 and 2 through COMBINER CHANNELS 15 and 16 are described in paragraphs 94 and 100.

*g*. Final tests for the LOOP BATTERY PANEL are described in paragraphs 83*g* and 84*f*.

# CHAPTER 6

# SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

## Section I. SHIPMENT AND LIMITED STORAGE

### 349. Disassembly

Telegraph Terminal AN/FGC–29 is fixed-plant equipment and will not be dismantled and shipped frequently, once it has been installed. The following procedures are recommended for preparing the equipment for shipment and limited storage.

*a.* Remove any patching cords from front panel jacks.

*b.* Set the OUTPUT VOLTAGE switch on the AC POWER SWITCHING PANEL (fig. 73) in cabinets 2, 4, and 6 to the UNREG positions.

*c.* Set the ON-OFF power switch (fig. 72) on the main power unit (located at the bottom rear of cabinets 1, 3, and 5) to the OFF position.

*d.* Take off the covers of the power terminal boxes (figs. 162–167) and intercabinet power wiring ducts (fig. 19) in cabinets 1 through 6. Turn off the primary power and remove the power and ground connections (fig. 35) from the power terminal boxes in cabinets 1, 3, and 5. Withdraw the power and ground leads through the intercabinet power wiring duct.

*e.* Remove the intercabinet power connections from the power terminal boxes in cabinets 1, 3, and 5. Pull the leads through the intercabinet power wiring duct from cabinet 1 to cabinet 2, from cabinets 5 and 3 to cabinet 4, and from cabinet 5 to cabinet 6. Coil the leads in the power terminal boxes of cabinets 2, 4, and 6, leaving one end attached to terminal boards TB131 through TB133. Replace the covers of the power terminal boxes and intercabinet power wiring ducts.

*f.* Disconnect the plugs on intercabinet cable assemblies W151 No. 1 through 7 (figs. 33 and 34) from the receptacles in cabinets 1 through 6. Pull the cable assemblies through the intercabinet signal wiring duct and remove.

*g.* Disconnect the four leads to terminal boards TB1 (fig. 168) on the voltage regulators in cabinets 2, 4, and 6 and remove the voltage regulators from these cabinets.

*h.* Remove the cover panels of cabinets 1 and 3 (figs. 4 and 6). Disconnect plugs P1 and P2 of the loop battery supplies from receptacles J2 and J4 on the loop battery panels in these cabinets and remove the four loop battery supplies (fig. 170). Replace the cover panels.

*i.* Arrange the drawers in cabinets 1 and 3 so that the multiplexers, demultiplexers, and audio frequency amplifiers are in the same positions as when the equipment was unpacked (figs. 134 and 136). Remove the dummy circuit panels (fig. 245), if necessary.

*j.* Disconnect all external connections from the terminal boards at the top rear of cabinets 1 through 6 (figs. 36 and 37).

*k.* Remove the bolts used to connect the cabinets of the transmitting terminal or the receiving terminal. Remove also, the four bolts used to fasten each cabinet to the floor (if used). Replace the bolt hole covers (figs. 168–170).

*l.* Withdraw all signal leads through the fittings in the roof opening, floor openings, or intercabinet signal duct openings (whichever was used at the time of installation). Replace the cover plates on roof openings, floor openings, intercabinet power wiring ducts, and intercabinet signal wiring ducts (fig. 19).

*m.* If the equipment is to be packaged for shipment or storage, replace the metal bracing (par. 46) at the rear of each cabinet, bolting it to the rear of the drawer type panels.

*n.* Secure all drawers and panels by tightening the four captive bolts, or the four mounting bolts, on the front panel of each unit. Replace the

dummy circuit panels in cabinet 3 and filler panels in cabinets 1, 2, 3, and 5 if necessary.

### 350. Repacking for Shipment or Limited Storage

*a.* The exact procedure in repacking for shipment or limited storage depends on the material available and the conditions under which the equipment is to be shipped or stored. Reverse the instructions in paragraph 46.

*b.* Replace the metal bracing at the rear of each cabinet and latch the cabinet doors. Pack each cabinet separately and place the voltage regulators, loop battery supplies, intercabinet cable assemblies W151, patching cords, Headset HS–110/G, and dummy circuit panels in a separate case with the running spares. Whenever practicable, place a dehydrating agent, such as silica gel, inside the corrugated cardboard carton. Protect the carton with a waterproof paper barrier. Seal the seams of the paper barrier with a waterproof sealing compound or tape. Pack the protected carton in a cleated packing case. Provide 3 inches of rubberized horsehair or other padding material between the paper barrier and the packing case.

## Section II. DEMOLITION OF MATERIEL TO PREVENT ENEMY USE

### 351. Authority for Demolition

The demolition procedure outlined in paragraph 352 will be used to prevent the enemy from using or salvaging this equipment. Demolition of the equipment will be accomplished only upon order of the commander.

### 352. Methods of Destruction

*a. Smash.* Smash the crystals, varistors, tubes, controls, meters, attenuators, switches, capacitors, terminal boards, transformers, and inductors; use sledges, pickaxes, hammers, crowbars, or other heavy tools.

*b. Cut.* Cut all power cords, patching cords, cables and wiring; use axes, handaxes, or machetes.

*c. Burn.* Burn cables, patching cords, resistors, capacitors, wiring, terminal boards, and technical manual; use gasoline, kerosene, oil, flame throwers, or incendiary grenades.

*d. Bend.* Bend panels, cabinets, doors, drawer slides, and chassis.

*e. Explosives.* If explosives are necessary, use firearms, grenades, or TNT.

*f. Disposal.* Burn or scatter the destroyed parts in slit trenches, foxholes, or other holes, or throw them into streams.

*Figure 248. Transmitting terminal, controls and test points, block diagram.*

(Contained in separate envelope)

*Figure 249. Receiving terminal, controls and test points, schematic diagram.*

(Sheet 1 of 2)

(Contained in separate envelope)

*Figure 249*—Continued.

(Sheet 2 of 2)

(Contained in separate envelope)

*Figure 250. Telegraph Terminal AN/FGC–29 arranged for 6-kc operation, block diagram.*

(Contained in separate envelope)

*Figure 251. Telegraph Terminal AN/FGC–29 arranged for 3-kc operation, block diagram.*

(Contained in separate envelope)

*Figure 252. Receiving terminal arranged for 6-kc operation, schematic diagram.*

(Sheet 1 of 2)

(Contained in separate envelope)

*Figure 252*—Continued.

(Sheet 2 of 2)

(Contained in separate envelope)

*Figure 253. Receiving terminal arranged for 3-kc operation, schematic diagram.*

(Sheet 1 of 2)

(Contained in separate envelope)

*Figure 253*—Continued.

(Sheet 2 of 2)

(Contained in separate envelope)

*Figure 254. Transmitter, schematic diagram.*

(Sheet 1 of 2)

(Contained in separate envelope)

*Figure 254*—Continued.

(Sheet 2 of 2)

(Contained in separate envelope)

*Figure 255. Receiver, schematic diagram.*

(Sheet 1 of 2)

(Contained in separate envelope)

*Figure 255*—Continued.

(Sheet 2 of 2)

(Contained in separate envelope)

*Figure 256. Combiner, schematic diagram.*

(Contained in separate envelope)

*Figure 257. Multiplexer TD–97/FGT–2, schematic diagram.*

(Contained in separate envelope)

*Figure 258. Demultiplexer TD–98/FGR–3, schematic diagram.*

(Contained in separate envelope)

*Figure 259. Audio Frequency Amplifier AM–911/FG, schematic diagram.*

(Contained in separate envelope)

*Figure 260. Transmitting terminal, ac power distribution, schematic diagram.*

(Contained in separate envelope)

*Figure 261. Receiving terminal, ac power distribution, schematic diagram.*

(Sheet 1 of 2)

(Contained in separate envelope)

*Figure 261*—Continued.

(Sheet 2 of 2)

(Contained in separate envelope)

*Figure 262. Cabinet 1, wiring diagram.*

(Contained in separate envelope)

*Figure 263. Cabinet 2, wiring diagram.*

(Contained in separate envelope)

*Figure 264. Cabinet 3, wiring diagram.*

(Contained in separate envelope)

*Figure 265. Cabinet 4, wiring diagram.*

(Contained in separate envelope)

*Figure 266. Cabinet 5, wiring diagram.*

(Contained in separate envelope)

*Figure 267. Cabinet 6, wiring diagram.*

(Contained in separate envelope)

*Figure 268. Transmitter, wiring diagram.*

(Contained in separate envelope)

NOTES:

1. WIRES NOT OTHERWISE SPECIFIED ARE 22 GAGE WITH NYLON JACKET.
2. BS DENOTES 22 GAGE TINNED, ANNEALED COPPER WIRING.
3. U DENOTES SHIELDED 22 GAGE WIRE WITH EXTRUDED NYLON JACKET.
4. PE DENOTES 22 GAGE WIRE WITH POLYETHYLENE INSULATION AND AND NYLON JACKET.
5. PE-U DENOTES 22 GAGE SHIELDED WIRE POLYETHYLENE INSULATION AND EXTRUDED NYLON JACKET.
6. D2 DENOTES WIRING RUN IN A SPECIFIC PATH AT TIME OF MANUFACTURE. ON REPLACEMENT OF D2 WIRING DO NOT DEVIATE FROM THIS PATH.
7. P20 DENOTES TWISTED PAIR 20 GAGE WITH NYLON JACKET.
8. PT DENOTES LEADS PART OF APPARATUS
9. D1 DENOTES WIRING CONNECTION FROM TERMINAL TO TERMINAL IN SHORTEST POSSIBLE MANNER.
10. PARTS MOUNTED ON TERMINALS THROUGH 16 ARE ON OPPOSITE SIDE OF TERMINAL BOARD FROM THOSE ON TERMINALS 17 THROUGH 32.
11. RESISTORS R9 THROUGH R13, R25 AND R26 ARE MOUNTED ON TOP SURFACE OF KEYER CHASSIS.
12. ⊂⊃ DENOTES SHIELDED CONNECTION.
13. TNC DENOTES TERMINAL NEAREST CHASSIS.

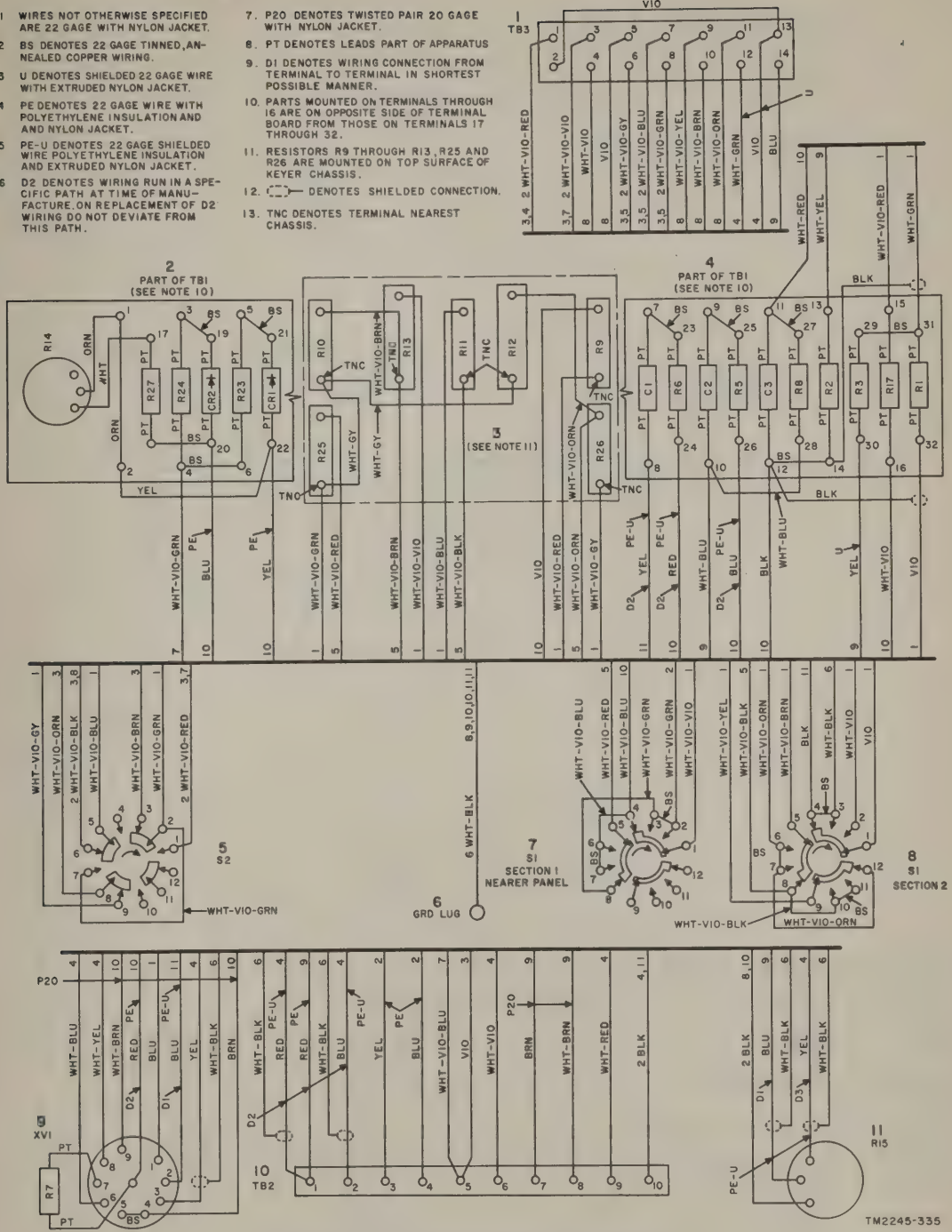



*Figure 269. Transmitter, keyer, wiring diagram.*

NOTES:

1. WIRES NOT OTHERWISE SPECIFIED ARE 22 GAGE WITH NYLON JACKET.
2. BS DENOTES 22 GAGE TINNED ANNEALED COPPER WIRING.
3. PT DENOTES LEADS PART OF APPARATUS.
4. CAPACITORS C7 THROUGH C9 AND C11 THROUGH C14 ARE MOUNTED ON UNDERSIDE OF TERMINAL BOARD TB4
5. CONNECTED AS REQUIRED FOR PROPER TUNING.

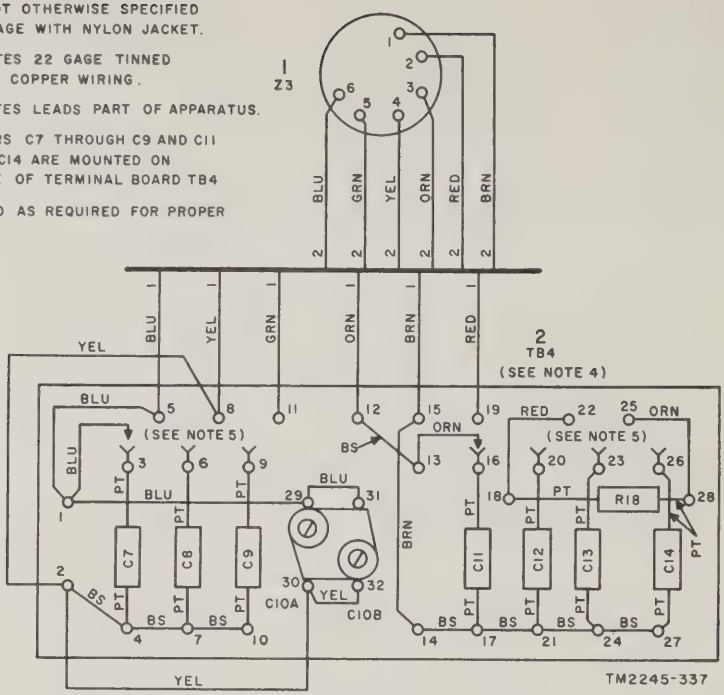



*Figure 270. Transmitter, oscillator tuner, wiring diagram*

NOTES:

1. THE SMALL NUMBER ON EACH WIRE (ADJACENT TO THE COMMON OR BASE LINE) CORRESPONDS TO THE LARGE NUMBER ADJACENT TO THE STATION TO WHICH THE WIRE RUNS.
2. WIRES NOT OTHERWISE SPECIFIED ARE 22 GAGE WITH NYLON JACKET.
3. BS DENOTES 22 GAGE TINNED, ANNEALED COPPER WIRING.
4. P20 DENOTES TWISTED PAIR 20 GAGE WITH NYLON JACKET.
5. PT DENOTES LEADS PART OF APPARATUS.

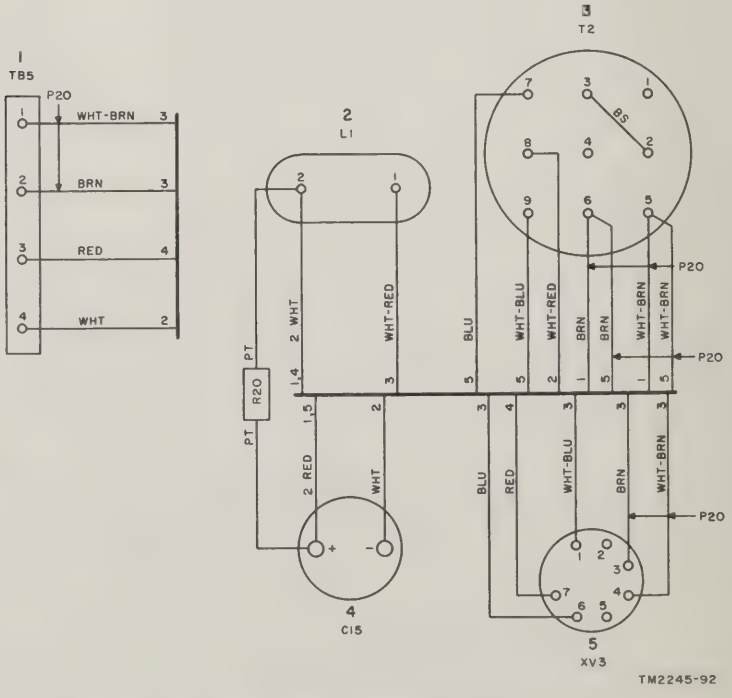



*Figure 271. Transmitter, bias supply, wiring diagram.*

*Figure 272. SUBGROUP MODULATOR, wiring diagram.*

(Contained in separate envelope)

*Figure 273. SUBGROUP MODULATOR, converter, wiring diagram.*

(Contained in separate envelope)

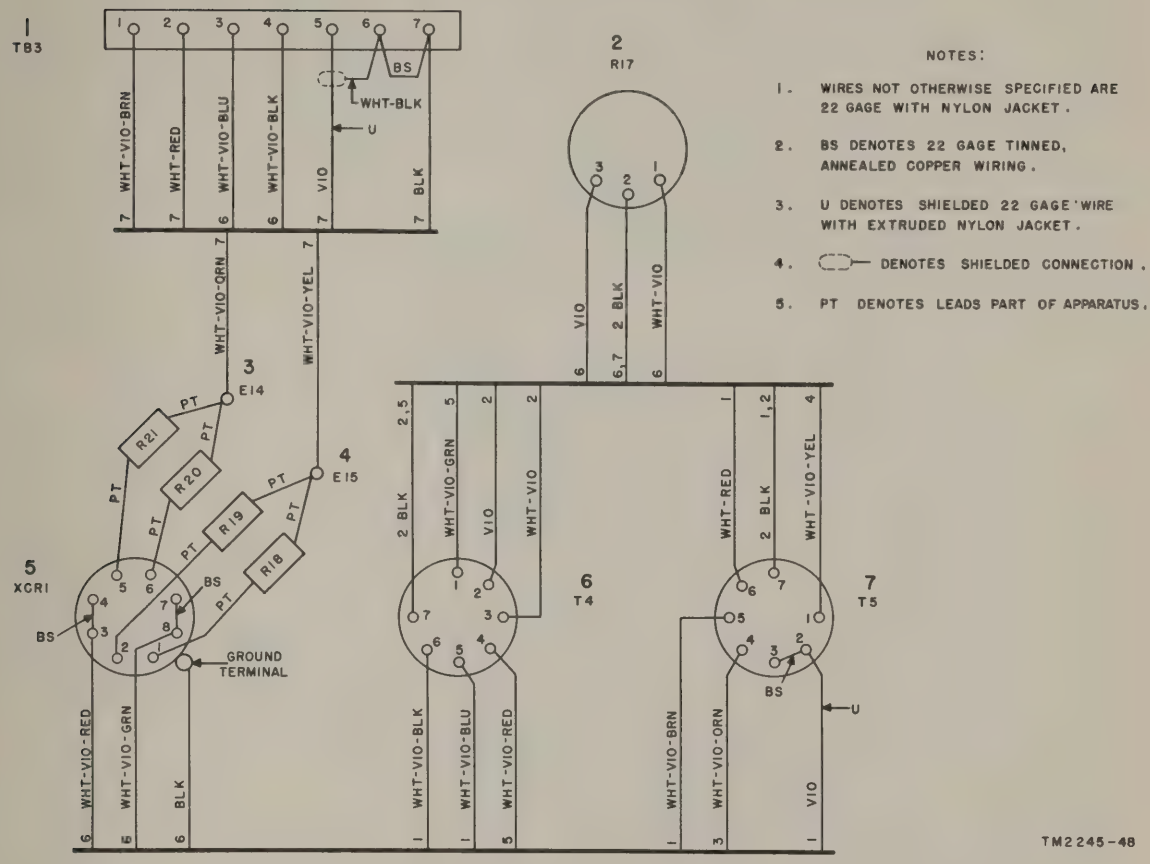



*Figure 274. Modulator, wiring diagram.*

*Figure 275. Carrier supply, wiring diagram.*

(Contained in separate envelope)

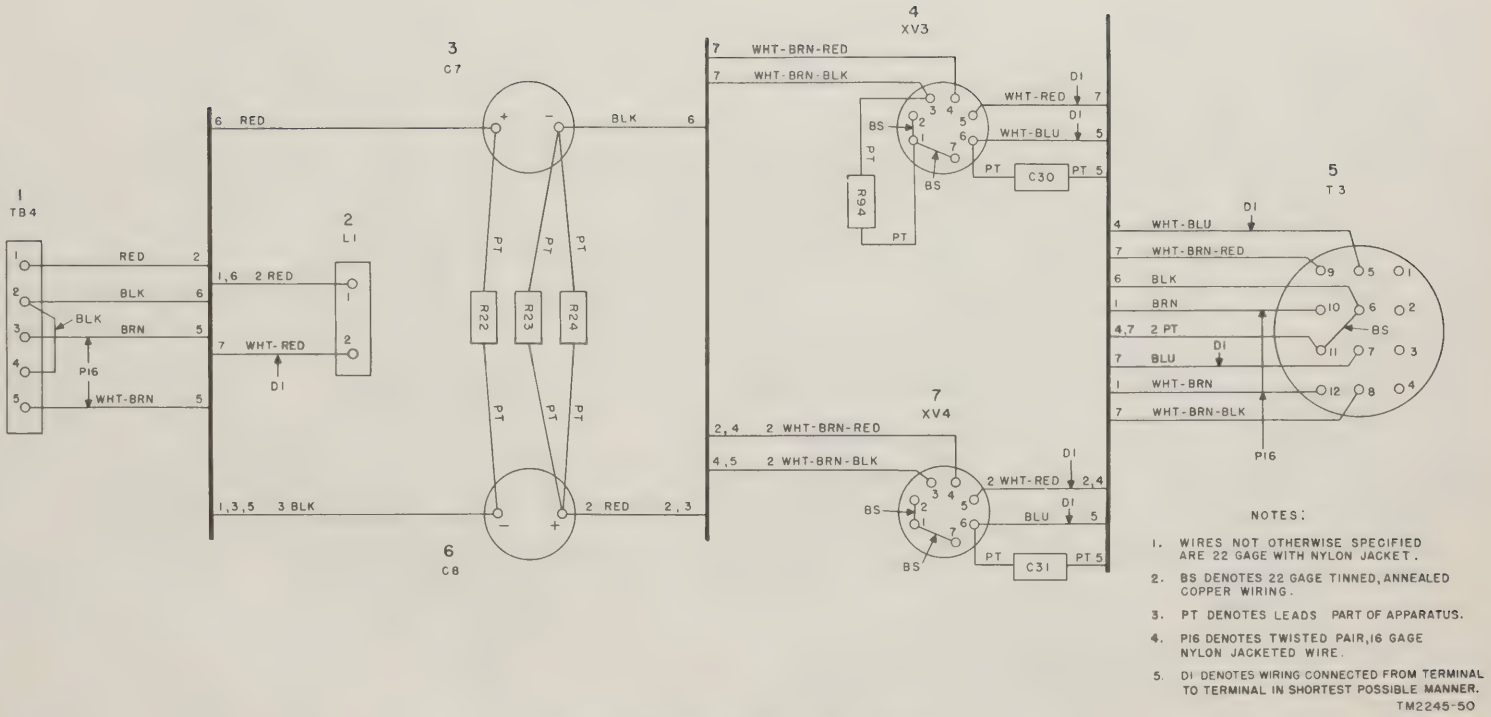
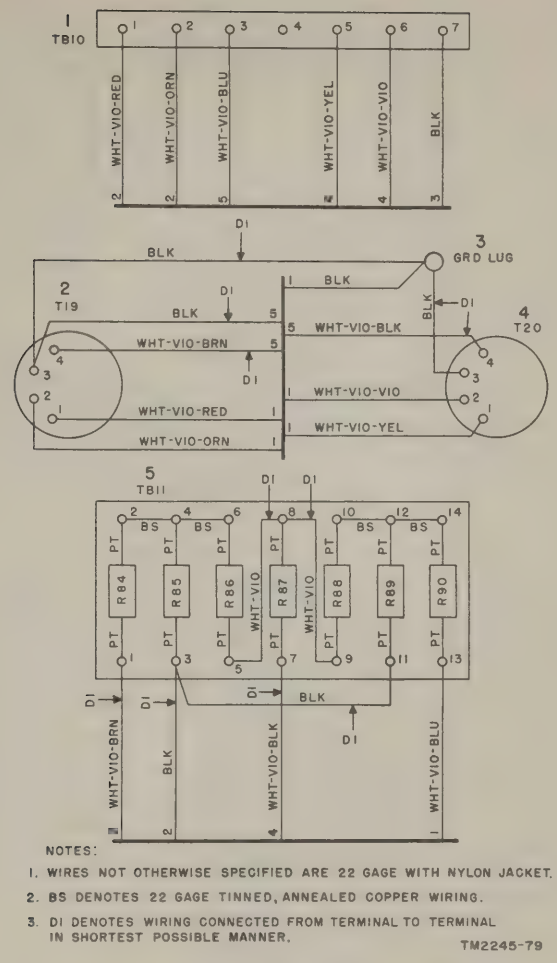



*Figure 276. Plate supply, wiring diagram.*




NOTES:

1. WIRES NOT OTHERWISE SPECIFIED ARE 22 GAGE WITH NYLON JACKET.
2. BS DENOTES 22 GAGE TINNED, ANNEALED COPPER WIRING.
3. DI DENOTES WIRING CONNECTED FROM TERMINAL TO TERMINAL IN SHORTEST POSSIBLE MANNER.

TM2245-79

*Figure 277. Output coupler, wiring diagram.*

*Figure 278. LEVEL CONTROL & PLATE SUPPLY, wiring diagram.*

(Contained in separate envelope)

*Figure 279. Line amplifier, wiring diagram.*

(Contained in separate envelope)

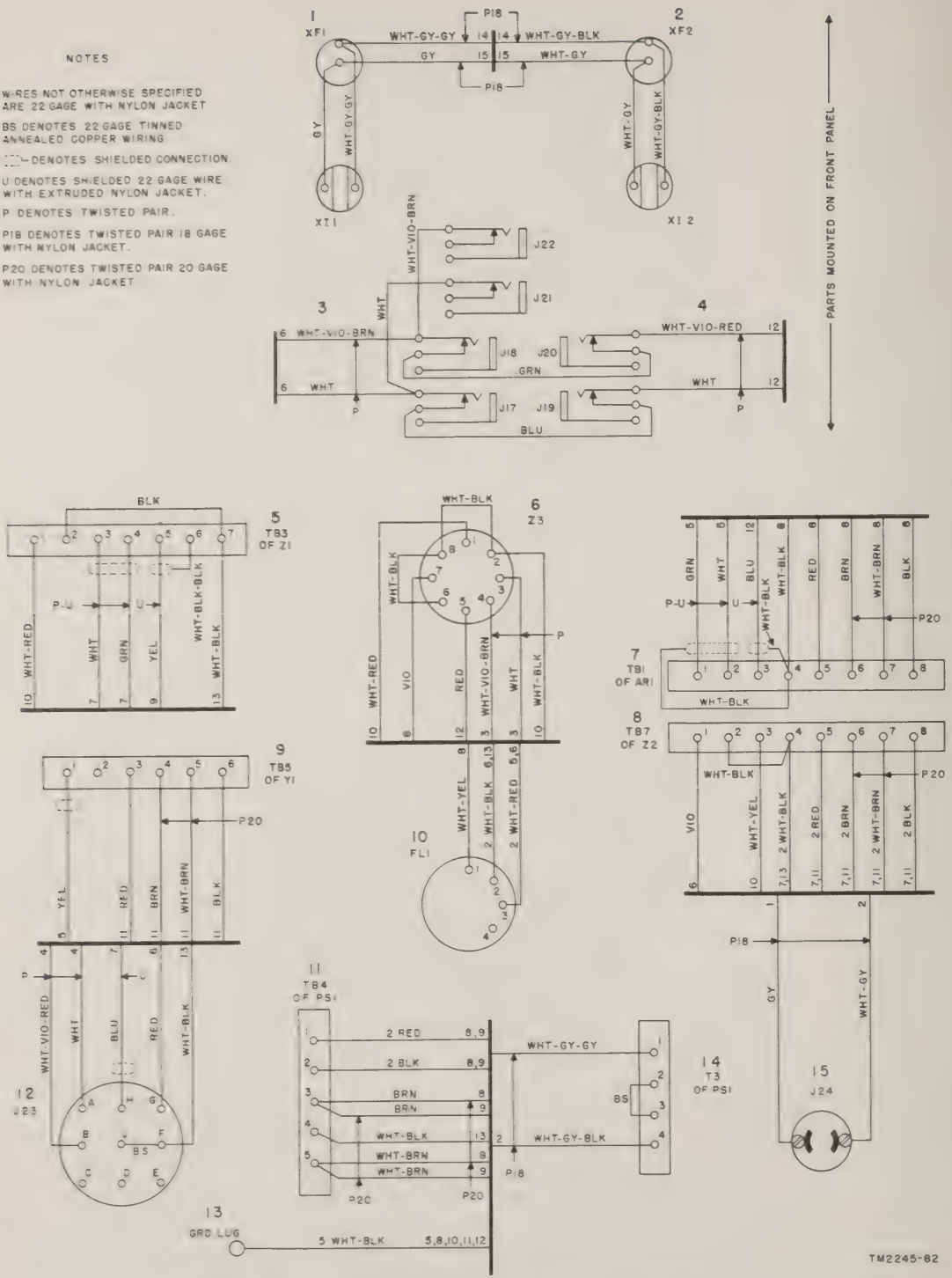



*Figure 280. SUBGROUP DEMODULATOR, wiring diagram.*

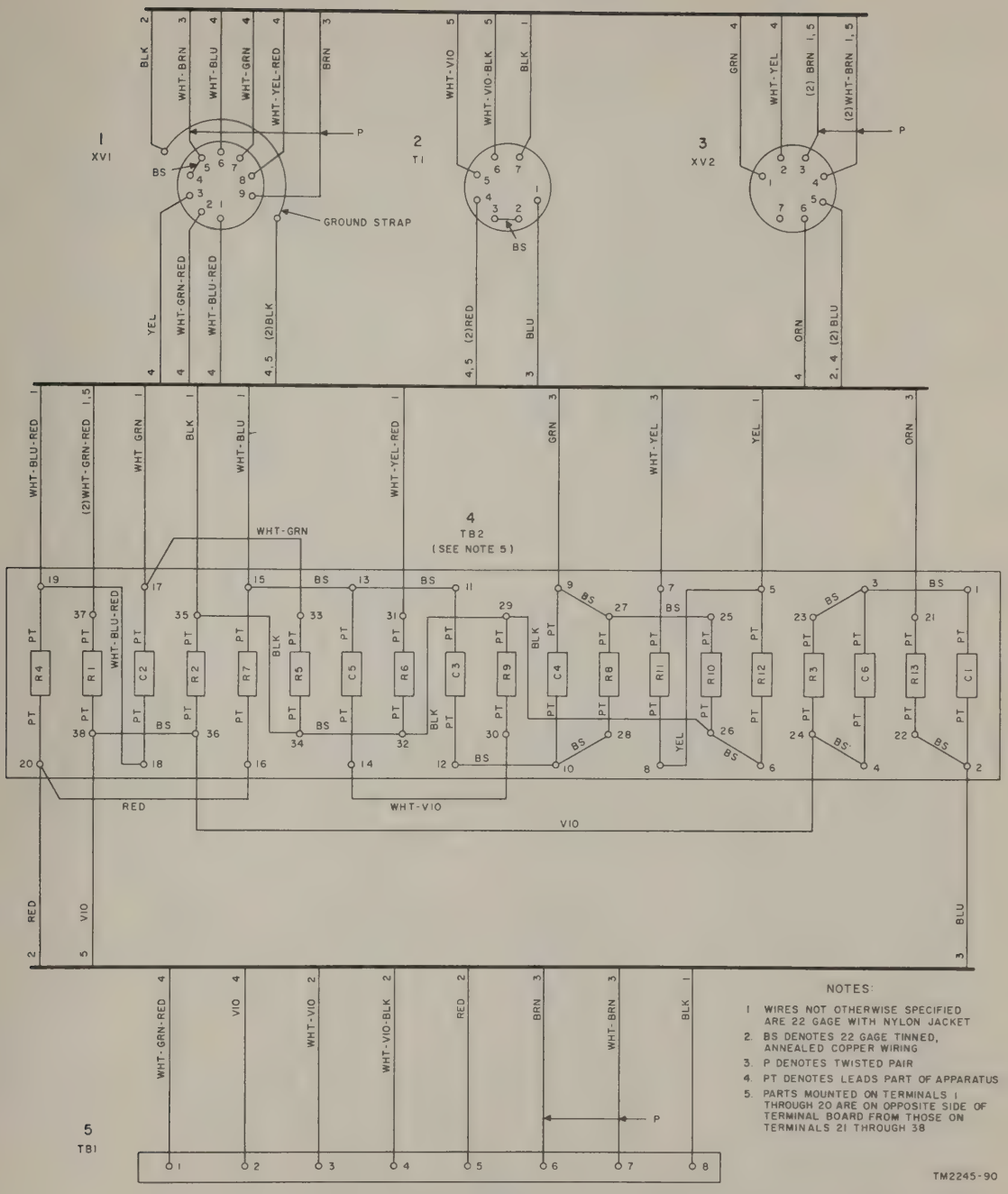


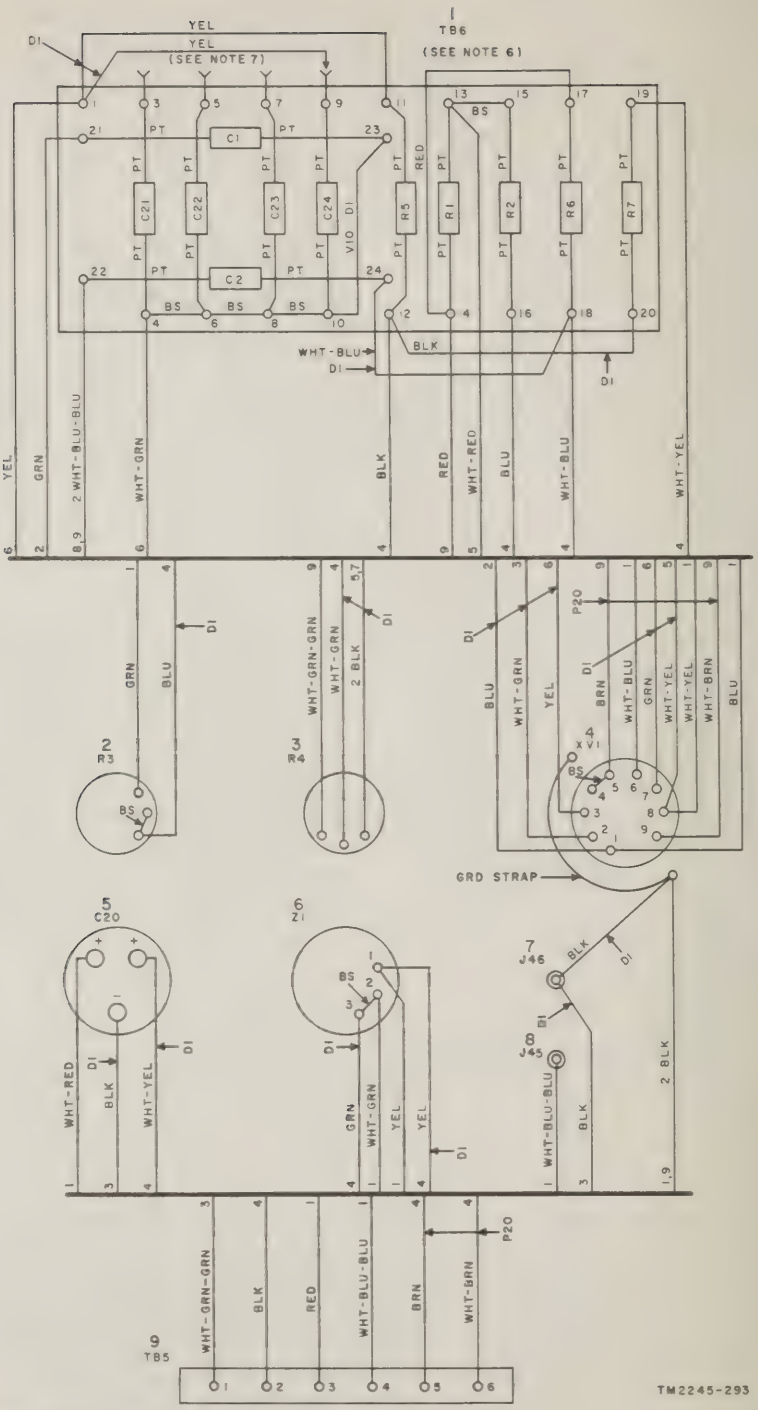

*Figure 281. SUBGROUP DEMODULATOR, band amplifier, wiring diagram.*

*Figure 282. Receiver, wiring diagram.*

(Contained in separate envelope)

*Figure 283. Agc amplifier, wiring diagram.*

(Contained in separate envelope)



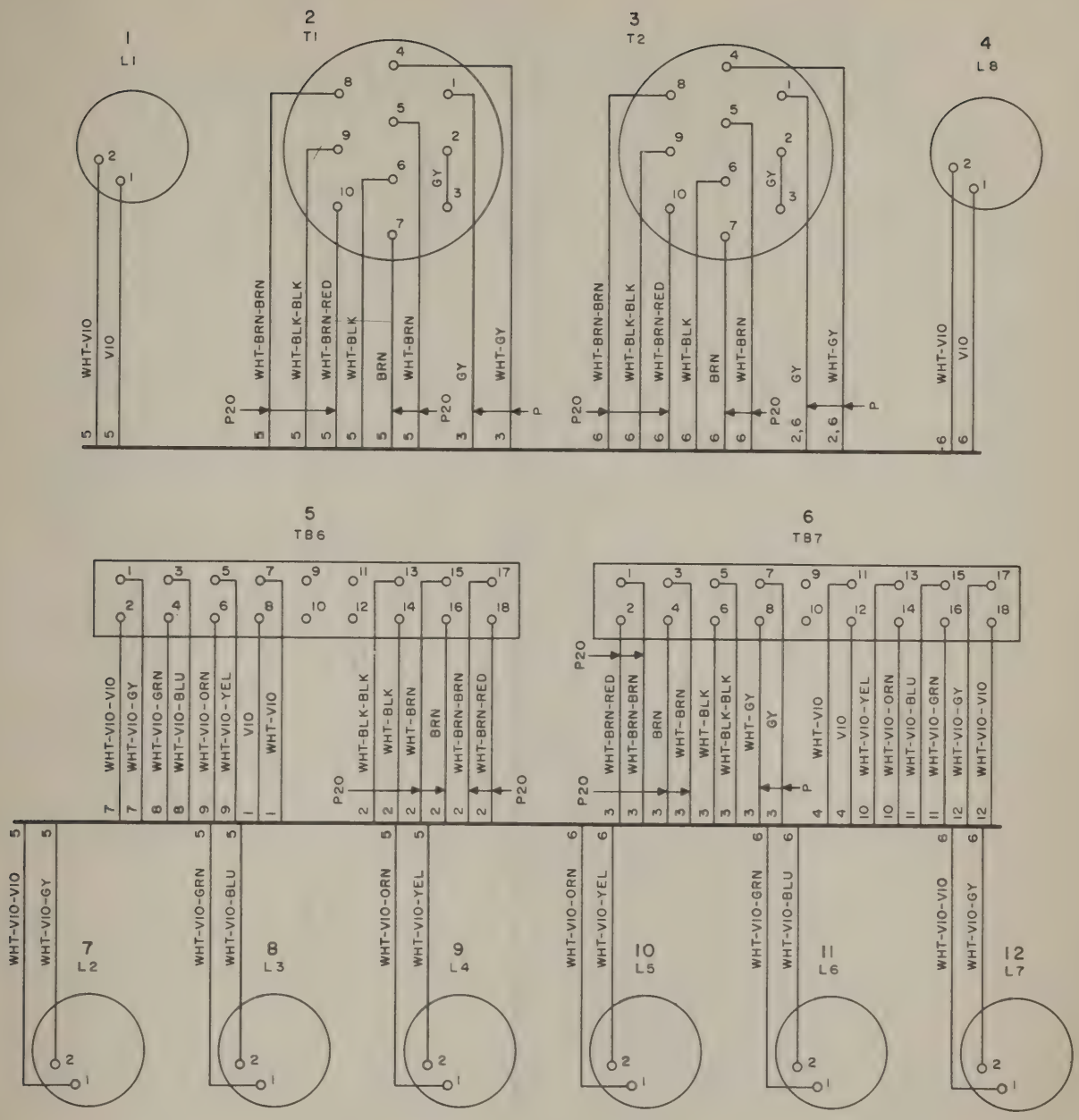

NOTES:

1. WIRES NOT OTHERWISE SPECIFIED ARE 22 GAGE WITH NYLON JACKET.
2. BS DENOTES 22 GAGE TINNED, ANNEALED COPPER WIRING.
3. P20 DENOTES TWISTED PAIR 20 GAGE WITH NYLON JACKET.
4. PT DENOTES LEADS PART OF APPARATUS.
5. DI DENOTES WIRING CONNECTED FROM TERMINAL TO TERMINAL IN SHORTEST POSSIBLE MANNER.
6. CAPACITORS C1 AND C2 ARE MOUNTED ON REAR OF TERMINAL BOARD.
7. CONNECTION IS MADE TO CAPACITORS C21 THROUGH C24 AS REQUIRED TO ADJUST FREQUENCY OF DELAY TUNER Z1.

*Figure 284. Delay amplifier, wiring diagram.*

*Figure 285. Combiner, wiring diagram.*

(Contained in separate envelope)




NOTES:

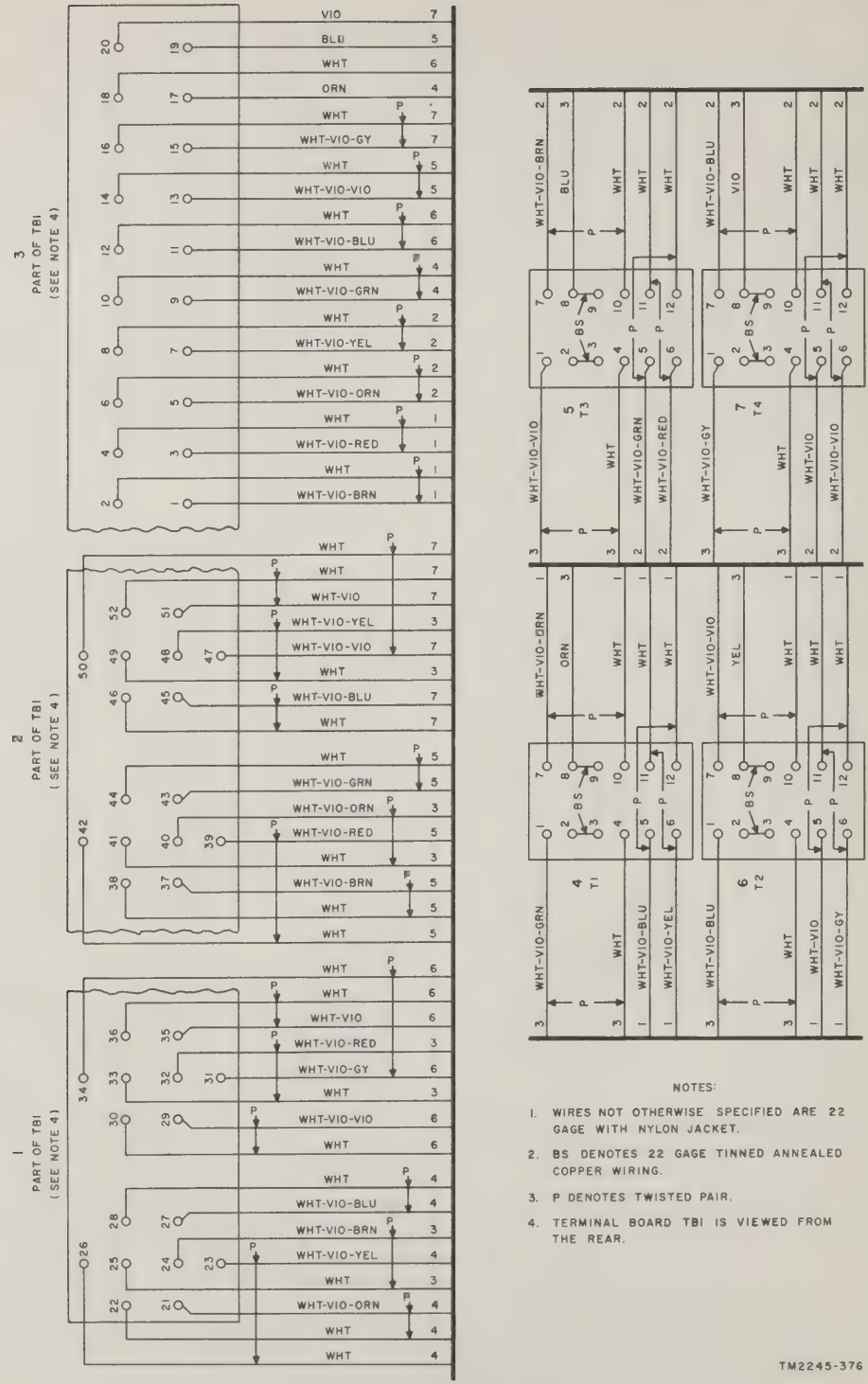
1. WIRES NOT OTHERWISE SPECIFIED ARE 22 GAGE WITH NYLON JACKET.
2. P DENOTES TWISTED PAIR 22 GAGE WITH NYLON JACKET.
3. P20 DENOTES TWISTED PAIR 20 GAGE WITH NYLON JACKET.

TM2245-88

*Figure 286. Combiner, transformer-reactor assembly, wiring diagram.*

*Figure 287. Adder, wiring diagram.*

(Contained in separate envelope)




NOTES:

1. WIRES NOT OTHERWISE SPECIFIED ARE 22 GAGE WITH NYLON JACKET.
2. BS DENOTES 22 GAGE TINNED ANNEALED COPPER WIRING.
3. P DENOTES TWISTED PAIR.
4. TERMINAL BOARD TBI IS VIEWED FROM THE REAR.

TM2245-376

*Figure 288. Transformer Assembly TF206-/FG, wiring diagram.*

*Figure 289. 3KC SEND BAND TEST PANEL, wiring diagram.*

(Contained in separate envelope)

*Figure 290. 3KC RECEIVE BAND TEST PANEL, wiring diagram.*

(Contained in separate envelope)

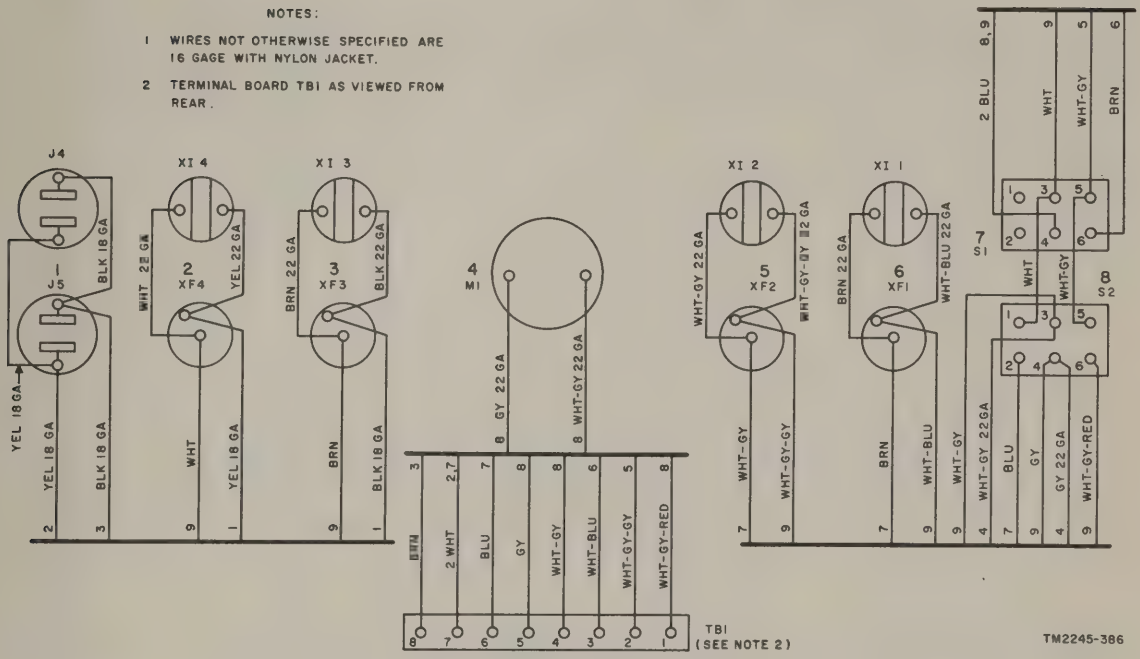
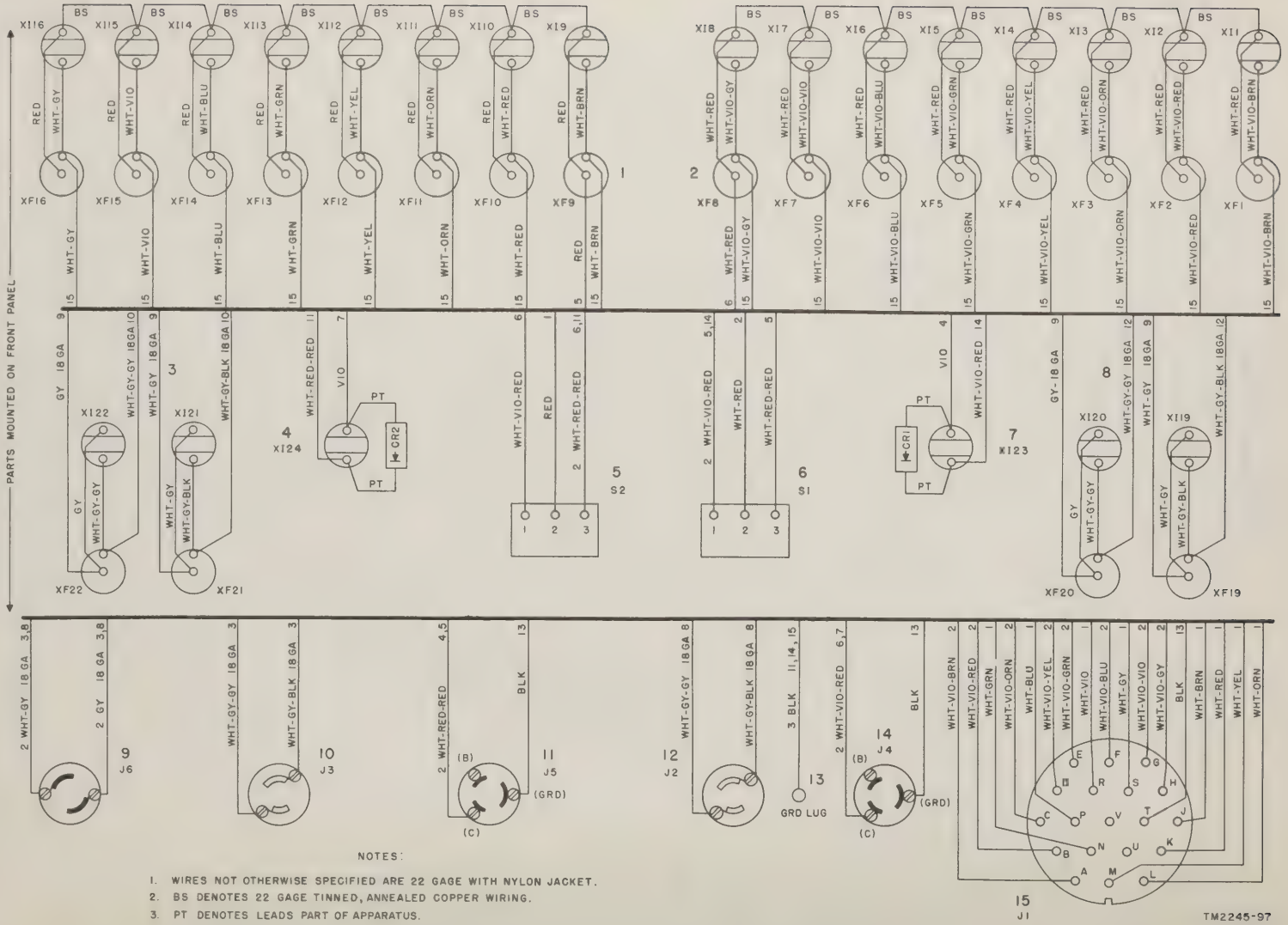



*Figure 291. AC POWER SWITCHING PANEL, wiring diagram.*

*Figure 292. Voltage regulator, wiring diagram.*

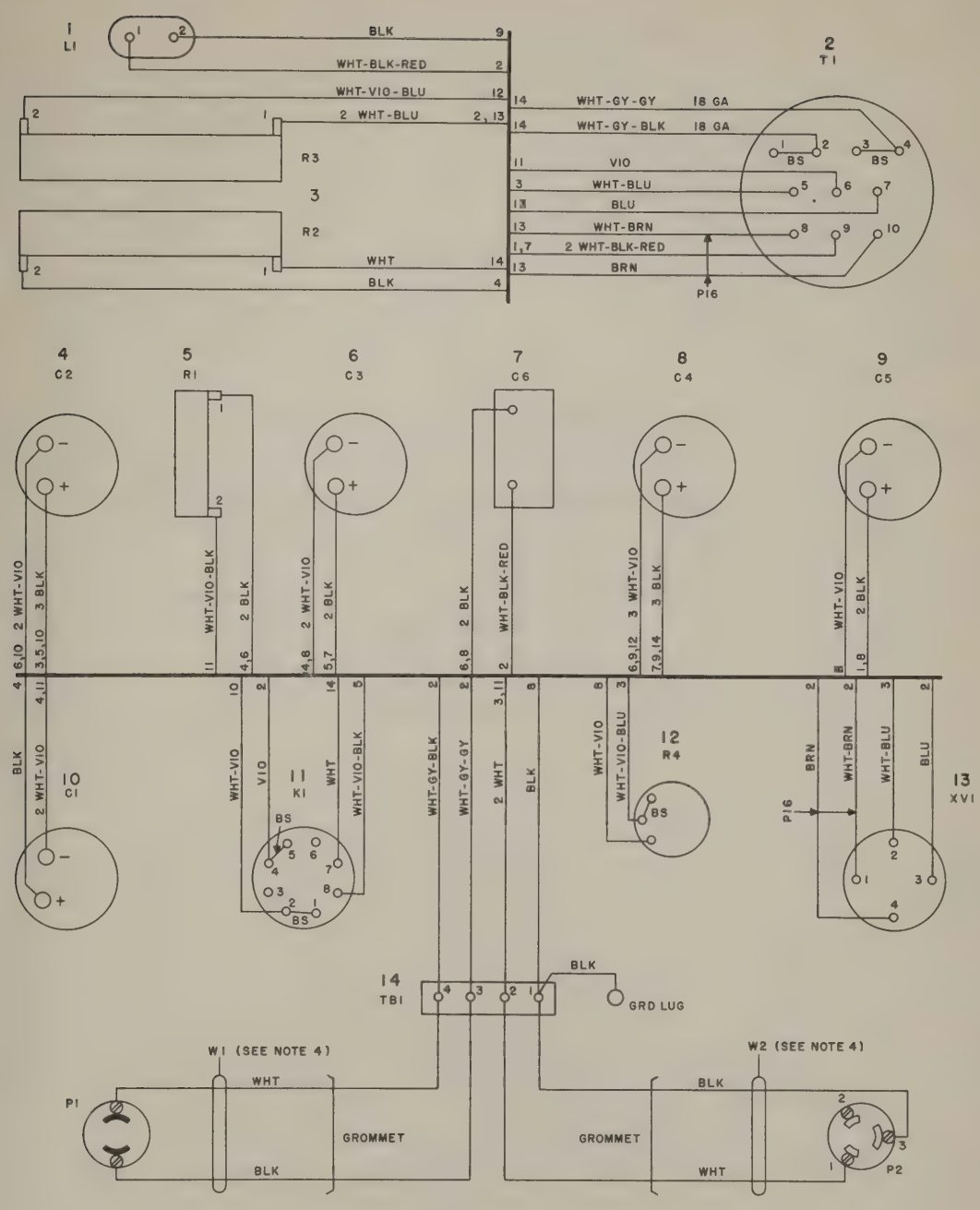
(Contained in separate envelope)




NOTES:

1. WIRES NOT OTHERWISE SPECIFIED ARE 22 GAGE WITH NYLON JACKET.
2. BS DENOTES 22 GAGE TINNED, ANNEALED COPPER WIRING.
3. PT DENOTES LEADS PART OF APPARATUS.

*Figure 293. LOOP BATTERY PANEL, wiring diagram.*




NOTES:

1. WIRES NOT OTHERWISE SPECIFIED ARE 22 GAGE WITH NYLON JACKET.
2. BS DENOTES 22 GAGE TINNED, ANNEALED COPPER WIRING.
3. P16 DENOTES TWISTED PAIR 16 GAGE WITH NYLON JACKET
4. CABLE ASSEMBLIES W1 AND W2 ARE MOLDED RUBBER CABLES WITH 16 GAGE CONDUCTORS.

TM2245-99

*Figure 294. Loop battery supply, wiring diagram.*

*Figure 295. TRANSMITTER METER PANEL, wiring diagram.*

*Figure 296. RECEIVER METER PANEL, wiring diagram.*

(Contained in separate envelope)

*Figure 297. DIVERSITY ALIGNMENT PANEL, wiring diagram.*

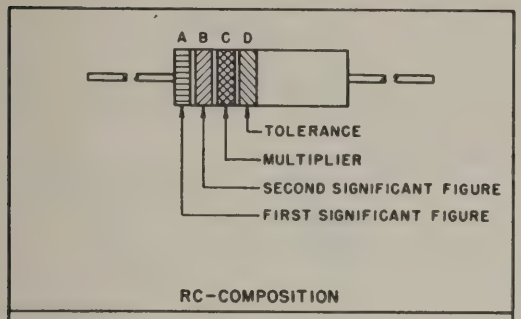
(Contained in separate envelope)

*Figure 298. RELAY PANEL, wiring diagram.*

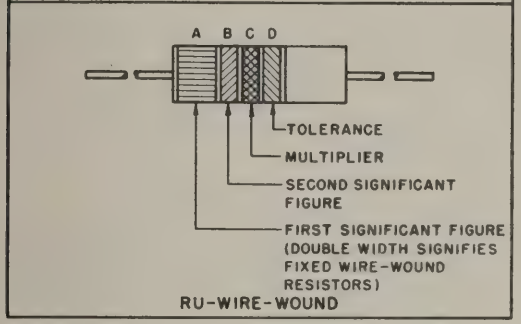
(Contained in separate envelope)

## RESISTOR COLOR CODE MARKING
## (MIL-STD RESISTORS)

### AXIAL-LEAD RESISTORS (INSULATED)

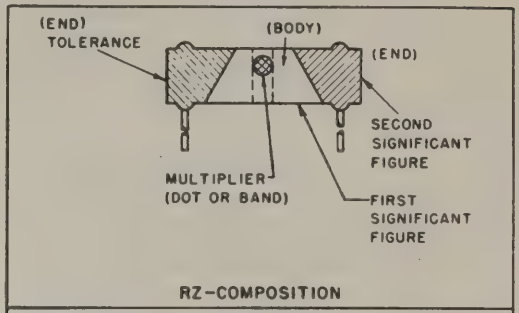



RC-COMPOSITION

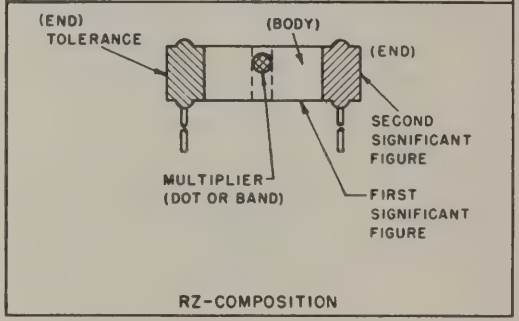



RU-WIRE-WOUND

### RADIAL-LEAD RESISTORS (UNINSULATED)




RZ-COMPOSITION




RZ-COMPOSITION

## RESISTOR COLOR CODE

| BAND A OR BODY* | | BAND B OR END* | | BAND C OR DOT OR BAND* | | BAND D OR END* | |
|---|---|---|---|---|---|---|---|
| COLOR | FIRST SIGNIFICANT FIGURE | COLOR | SECOND SIGNIFICANT FIGURE | COLOR | MULTIPLIER | COLOR | RESISTANCE TOLERANCE (PERCENT) |
| BLACK | 0 | BLACK | 0 | BLACK | 1 | BODY | ± 20 |
| BROWN | 1 | BROWN | 1 | BROWN | 10 | SILVER | ± 10 |
| RED | 2 | RED | 2 | RED | 100 | GOLD | ± 5 |
| ORANGE | 3 | ORANGE | 3 | ORANGE | 1,000 | | |
| YELLOW | 4 | YELLOW | 4 | YELLOW | 10,000 | | |
| GREEN | 5 | GREEN | 5 | GREEN | 100,000 | | |
| BLUE | 6 | BLUE | 6 | BLUE | 1,000,000 | | |
| PURPLE (VIOLET) | 7 | PURPLE (VIOLET) | 7 | | | | |
| GRAY | 8 | GRAY | 8 | GOLD | 0.1 | | |
| WHITE | 9 | WHITE | 9 | SILVER | 0.01 | | |

*FOR WIRE-WOUND-TYPE RESISTORS, BAND A SHALL BE DOUBLE-WIDTH. WHEN BODY COLOR IS THE SAME AS THE DOT (OR BAND) OR END COLOR, THE COLORS ARE DIFFERENTIATED BY SHADE, GLOSS, OR OTHER MEANS.

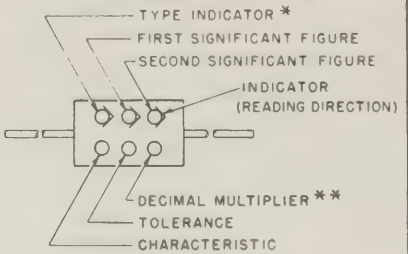
EXAMPLES (BAND MARKING):
10 OHMS ±20 PERCENT: BROWN BAND A; BLACK BAND B; BLACK BAND C; NO BAND D.
4.7 OHMS ±5 PERCENT: YELLOW BAND A; PURPLE BAND B; GOLD BAND C; GOLD BAND D.

EXAMPLES (BODY MARKING):
10 OHMS ±20 PERCENT: BROWN BODY; BLACK END; BLACK DOT OR BAND; BODY COLOR ON TOLERANCE END.
3,000 OHMS ±10 PERCENT: ORANGE BODY, BLACK END, RED DOT OR BAND; SILVER END

STD-RI

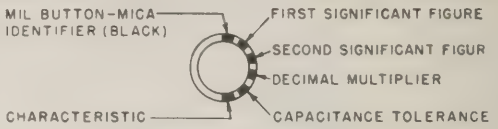
*Figure 299. MIL STD capacitor color code chart.*

## CAPACITOR COLOR CODE MARKING
## (MIL-STD CAPACITORS)

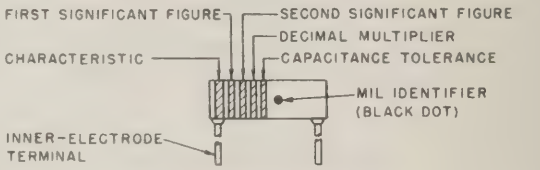


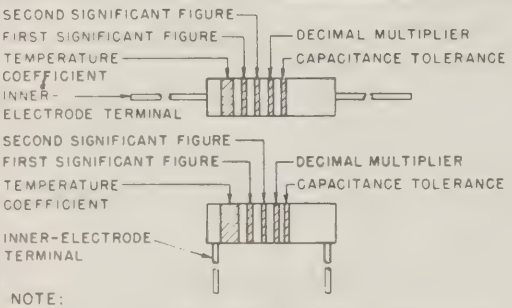

* BLACK DOT MICA DIELECTRIC
SILVER DOT PAPER DIELECTRIC
** INDICATES NUMBER OF ZEROS ON PAPER TYPE

MICA (CM) AND PAPER (CN)



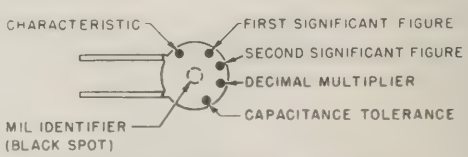

BUTTON-MICA (CB)




NOTE:
SPOTS MAY BE USED INSTEAD OF BANDS, TEMPERATURE COEFFICIENT MARKING IS LARGER

CERAMIC-TEMPERATURE COMPENSATING (CC)




NOTES:
1. SPOTS MAY BE USED ON TUBULAR CAPACITORS, CHARACTERISTIC SPOT IS LARGER AND MIL IDENTIFIER IS ON SIDE DIAMETRICALLY OPPOSITE COLOR SPOTS.
2. MIL IDENTIFIER OF DISK TYPE IS ON REVERSE SIDE; CHARACTERISTIC SPOT IS LARGER OR SPACE BETWEEN CHARACTERISTIC AND TOLERANCE SPOTS IS THREE TIMES SPACE BETWEEN ADJACENT SPOTS.
3. TOLERANCE: YELLOW, +100%, -20%.

CERAMIC-GENERAL PURPOSE (CK)

## CAPACITOR COLOR CODE

| COLOR | SIG FIG. | MULTIPLIER | | CHARACTERISTIC[1] | | | | TOLERANCE[2] | | | | | TEMPERATURE COEFFICIENT (UUF/UF/°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DECIMAL | NUMBER OF ZEROS | CM | CN | CB | CK | CM | CN | CB | CC | | |
| | | | | | | | | | | | OVER 10UUF | 10UUF OR LESS | CC |
| BLACK | 0 | 1 | NONE | | A | | | 20 | 20 | 20 | 20 | 2 | ZERO |
| BROWN | 1 | 10 | 1 | B | E | B | W | | | | 1 | | -30 |
| RED | 2 | 100 | 2 | C | H | | X | 2 | | 2 | 2 | | -80 |
| ORANGE | 3 | 1,000 | 3 | D | J | D | | | 30 | | | | -150 |
| YELLOW | 4 | 10,000 | 4 | E | P | | | | | | | | -220 |
| GREEN | 5 | | 5 | F | R | | | | | | 5 | 0.5 | -330 |
| BLUE | 6 | | 6 | | S | | | | | | | | -470 |
| PURPLE (VIOLET) | 7 | | 7 | | T | W | | | | | | | -750 |
| GRAY | 8 | | 8 | | | X | | | | | | 0.25 | +30 |
| WHITE | 9 | | 9 | | | | | | | | 10 | 1 | -330(±500)[3] |
| GOLD | | 0.1 | | | | | | 5 | | 5 | | | +100 |
| SILVER | | 0.01 | | | | | | 10 | 10 | 10 | | | |

1. LETTERS ARE IN TYPE DESIGNATIONS GIVEN IN MIL-C SPECIFICATIONS.
2. IN PERCENT, EXCEPT IN UUF FOR CC-TYPE CAPACITORS OF 10 UUF OR LESS.
3. INTENDED FOR USE IN CIRCUITS NOT REQUIRING COMPENSATION

STD-C1

*Figure 300. MIL STD resistor color code chart.*

# INDEX


| | Paragraph | Page |
|---|---|---|
| Accessories, description | 25 | 16 |
| Ac power distribution: | | |
| General | 210 | 239 |
| Receiving terminal | 212 | 240 |
| System, trouble sectionalization | 252 | 282 |
| Transmitting terminal | 211 | 239 |
| AC POWER SWITCHING PANEL: | | |
| Access to parts | 245*f* | 279 |
| Controls | 78 | 99 |
| Operational test | 310 | 389 |
| Theory | 213 | 241 |
| Trouble localization | 312 | 391 |
| Troubleshooting chart | 311 | 390 |
| Adder: | | |
| Theory. (*See* Combiner, schematic diagram analysis.) | | |
| Trouble isolation | 307 | 382 |
| Additional equipment required | 36 | 22 |
| Additional troubleshooting information: | | |
| Combiner | 309 | 387 |
| DIVERSITY ALIGNMENT PANEL | 335 | 418 |
| LEVEL CONTROL & PLATE SUPPLY | 281 | 342 |
| Loop battery supply | 323 | 402 |
| Main power unit | 337 | 419 |
| Receiver | 303 | 373 |
| RECEIVER METER PANEL | 331 | 413 |
| RELAY PANEL | 342 | 423 |
| SUBGROUP DEMODULATOR | 294 | 358 |
| SUBGROUP MODULATOR | 275 | 334 |
| Transmitter | 266 | 313 |
| TRANSMITTER METER PANEL | 327 | 407 |
| Voltage regulator | 316 | 395 |
| Agc amplifier: | | |
| Block diagram analysis | 184 | 192 |
| Schematic diagram analysis | 185 | 195 |
| Trouble isolation | 299 | 365 |
| Air filter, cleaning and oiling | 234*b* | 270 |
| Arctic climates, operation | 126 | 138 |
| Attenuators: | | |
| Lubrication | 234 | 270 |
| Tests | 249 | 281 |
| Audio Frequency Amplifier AM–911/FG: | | |
| Block diagram analysis | 197 | 219 |
| Controls | 71 | 86 |
| Description | 34 | 21 |
| General function | 132 | 140 |
| Installation planning | 39*d* | 25 |
| Locations, optional | 48 | 39 |
| Technical characteristics | 15 | 9 |
| Authority for demolition | 351 | 427 |
| Auxiliary components, general theory | 140 | 146 |
| Band amplifier: | | |
| Block diagram analysis | 175 | 184 |
| Schematic diagram analysis | 176 | 186 |
| Trouble isolation | 291 | 355 |
| Bias supply: | | |
| Schematic diagram analysis | 152 | 157 |
| Trouble isolation | 262 | 308 |
| Block diagram analysis: | | |
| Agc amplifier | 184 | 192 |
| Audio Frequency Amplifier AM–911/FG | 197 | 219 |
| Band amplifier | 175 | 184 |
| Carrier supply | 162 | 168 |
| Combiner | 189 | 203 |
| Converter | 158 | 163 |
| DELAY ADJUST METER circuit | 227*c* | 260 |
| Demultiplexer TD–98/FGR–3 | 196 | 219 |
| DIVERSITY ALIGNMENT PANEL | 229 | 267 |
| Dotter circuit | 225*c* | 255 |
| LEVEL CONTROL & PLATE SUPPLY | 168 | 178 |
| LEVEL METER circuit, RECEIVER METAL PANEL | 227*a* | 260 |
| LEVEL METER circuit, TRANSMITTER METER PANEL | 225*a* | 255 |
| Line amplifier | 170 | 180 |
| LOOP CURRENT METER circuit, RECEIVER METER PANEL | 227*b* | 260 |
| LOOP CURRENT METER circuit, TRANSMITTER METER PANEL | 225*b* | 255 |
| Multiplexer TD–97/FGT–2 | 195 | 217 |
| Receiver | 181 | 188 |
| SUBGROUP DEMODULATOR | 173 | 181 |
| SUBGROUP MODULATOR | 156 | 160 |
| Transmitter | 143 | 148 |
| TRANSMITTER METER PANEL | 225 | 255 |
| Voltage regulator | 214 | 242 |
| Blower motor: | | |
| Controls | 81 | 105 |
| Lubrication | 235 | 271 |
| B-plus power distribution: | | |
| General | 216*a* | 247 |
| Receiving terminal | 218 | 249 |
| System, trouble sectionalization | 254 | 283 |
| Transmitting terminal | 217 | 247 |
| Branching network, diversity alignment panel: | | |
| Block diagram analysis | 229 | 267 |
| Schematic diagram analysis | 230 | 268 |

| | Paragraph | Page |
|---|---|---|
| Cabinet: | | |
| Cording | 49 | 40 |
| Description | 18*b* | 10 |
| Interconnections | 50 | 41 |
| Number in terminal | 6*h* | 5 |
| Relay rack | 36*a* | 22 |
| Carrier supply: | | |
| SUBGROUP DEMODULATOR: | | |
| Theory | 178 | 187 |
| Trouble isolation | 292 | 355 |
| SUBGROUP MODULATOR: | | |
| Block diagram analysis | 162 | 168 |
| Schematic diagram analysis | 163 | 170 |
| Trouble isolation | 272 | 325 |
| Carrier telephone facilities | 44 | 34 |
| Combiner: | | |
| Access to parts | 245*a* | 278 |
| Additional troubleshooting information | 309 | 387 |
| Block diagram analysis | 189 | 203 |
| Controls | 68 | 79 |
| Description | 31 | 20 |
| External power connections | 192 | 215 |
| Operational test | 304 | 375 |
| Schematic diagram analysis | 190 | 205 |
| Technical characteristics | 12 | 8 |
| Trouble localization | 306 | 379 |
| Troubleshooting chart | 305 | 376 |
| Common names | 4 | 1 |
| Components, table | 16 | 10 |
| Controls: | | |
| AC POWER SWITCHING PANEL | 78 | 99 |
| Audio Frequency Amplifier AM–911/FG | 71 | 86 |
| Blower motor | 81 | 105 |
| Combiner | 68 | 79 |
| Demultiplexer TD–98/FGR–3 | 72 | 87 |
| DIVERSITY ALIGNMENT PANEL | 76 | 96 |
| LEVEL CONTROL & PLATE SUPPLY | 65 | 68 |
| LOOP BATTERY PANEL | 80 | 101 |
| Lubrication | 234 | 270 |
| Main power unit | 77 | 99 |
| Multiplexer TD–97/FGT–2 | 70 | 85 |
| Receiver | 67 | 74 |
| RECEIVER METER PANEL | 75 | 93 |
| SUBGROUP DEMODULATOR | 66 | 69 |
| SUBGROUP MODULATOR | 64 | 67 |
| 3KC RECEIVE BAND TEST PANEL | 73 | 92 |
| 3KC SEND BAND TEST PANEL | 69 | 79 |
| Transmitter | 63 | 64 |
| TRANSMITTER METER PANEL | 74 | 92 |
| Voltage regulator | 79 | 99 |
| Converter: | | |
| SUBGROUP DEMODULATOR: | | |
| Theory | 178 | 187 |
| Trouble isolation | 292 | 355 |
| SUBGROUP MODULATOR: | | |
| Block diagram analysis | 158 | 163 |
| Schematic diagram analysis | 159 | 165 |
| Trouble isolation | 270 | 321 |
| Cording, cabinet: | | |
| Connections: | | |
| 6–kc operation | 49*a* | 41 |
| 3–kc operation | 49*b* | 41 |
| Dc power distribution circuits: | | |
| General | 216 | 247 |
| Receiving terminal: | | |
| B-plus voltage | 218 | 249 |
| Loop battery | 220 | 250 |
| Transmitting terminal: | | |
| B-plus voltage | 217 | 247 |
| Loop battery | 219 | 249 |
| DELAY ADJUST METER circuit, RECEIVER METER PANEL: | | |
| Block diagram analysis | 227 | 259 |
| Schematic diagram analysis | 228 | 260 |
| Delay amplifier AR1 or AR2: | | |
| Theory | 183 | 190 |
| Trouble isolation | 298 | 364 |
| Delay tuner: | | |
| Tests | 301 | 371 |
| Theory. (*See* Delay amplifier AR1 or AR2, theory.) | | |
| Demod filter 1: | | |
| Tests | 293 | 355 |
| Theory | 177 | 186 |
| Demolition: | | |
| Authority | 351 | 427 |
| Methods | 352 | 427 |
| Demultiplexer TD–98/FGR–3: | | |
| Block diagram analysis | 196 | 219 |
| Controls | 72 | 87 |
| Description | 33 | 21 |
| General function | 131 | 140 |
| Installation planning | 39*c* | 25 |
| Locations, optional | 48 | 39 |
| Technical characteristics | 14 | 9 |
| Description: | | |
| Accessories | 25 | 16 |
| Audio Frequency Amplifier AM–911/FG | 34 | 21 |
| Cabinet 1 | 19 | 11 |
| Cabinet 2 | 20 | 11 |
| Cabinet 3 | 21 | 11 |
| Cabinet 4 | 22 | 11 |
| Cabinet 5 | 23 | 11 |
| Cabinet 6 | 24 | 16 |
| Combiner | 31 | 20 |
| Demultiplexer TD–98/FGR–3 | 33 | 21 |
| LEVEL CONTROL & PLATE SUPPLY | 28 | 16 |
| Multiplexer TD–97/FGT–2 | 32 | 21 |
| Receiver | 30 | 20 |
| SUBGROUP DEMODULATOR | 29 | 20 |
| SUBGROUP MODULATOR | 27 | 16 |
| Transmitter | 26 | 16 |
| Desert climates, operation | 126 | 138 |
| Disassembly | 349 | 426 |
| Discriminator: | | |
| Tests | 308 | 385 |
| Theory | 193 | 215 |

| | Paragraph | Page |
|---|---|---|
| Diversity alignment circuit, DIVERSITY ALIGNMENT PANEL: | | |
| Block diagram analysis | 229 | 267 |
| Schematic diagram analysis | 230 | 268 |
| DIVERSITY ALIGNMENT PANEL: | | |
| Access to parts | 245*b* | 279 |
| Additional troubleshooting information | 335 | 418 |
| Block diagram analysis | 229 | 267 |
| Controls | 76 | 96 |
| Operational test | 332 | 414 |
| Schematic diagram analysis | 230 | 268 |
| Theory, general | 140*c* | 147 |
| Trouble localization | 334 | 416 |
| Troubleshooting chart | 333 | 414 |
| Diversity combining | 5*e* | 5 |
| Four-channel | 38*a*(2) | 23 |
| Two-channel | 38*a*(1) | 23 |
| Diversity radio operation, theory | 134 | 141 |
| Domestic packing cases, unpacking | 46*b* | 35 |
| Dotter circuit, TRANSMITTER METER PANEL: | | |
| Block diagram analysis | 225 | 255 |
| Schematic diagram analysis | 226 | 256 |
| Drawer slides: | | |
| Lubrication | 233 | 270 |
| Operation | 58 | 59 |
| Drawer-type components: | | |
| Description | 18*c* | 10 |
| Removing from cabinet | 58*b* | 60 |
| Replacing in cabinet | 58*c* | 60 |
| Withdrawing from cabinet | 58*a* | 59 |
| DUMMY CIRCUIT PANEL: | | |
| Description | 25 | 16 |
| Troubleshooting | 340 | 420 |
| Electrical Headset H–110/G | 36*c* | 22 |
| Emergency operation | 120 | 136 |
| Expanding circuit, Agc amplifier: | | |
| Block diagram analysis | 184*a* | 193 |
| Schematic diagram analysis | 185*a* | 217 |
| External power and ground connections | 51 | 43 |
| External signal connections | 52 | 46 |
| Facsimile operation with carrier telephone facilities | 44*b* | 34 |
| Facsimile service | 43*c* | 34 |
| Fading, selective | 133*b* | 141 |
| Filter tests: | | |
| Receiver | 302 | 373 |
| SUBGROUP DEMODULATOR | 293 | 355 |
| SUBGROUP MODULATOR | 274 | 330 |
| Transmitter | 265 | 312 |
| Final tests: | | |
| General | 346 | 424 |
| Precautions | 347 | 424 |
| Floor opening, use: | | |
| Power connections | 51*a*(3) | 45 |
| Signal connections | 52*a*(3) | 47 |
| Forms and records | 2 | 1 |
| Frequency diversity: | | |
| Routing connections: | | |
| Receiving terminal | 57 | 57 |
| Transmitting terminal | 56 | 55 |
| 6-kc line facilities | 40*c*(2) | 27 |
| Telegraph service | 38*a*(4) | 24 |
| Theory | 134*a* | 141 |
| 3-kc line facilities | 41*c*(2) | 32 |
| Frequency divider circuit, 19.38–kc to 9.69–kc, converter, schematic diagram analysis | 159*b* | 165 |
| Frequency divider circuit, 25.16–kc to 6.29–kc, carrier supply, schematic diagram analysis | 163*b* | 171 |
| Fungiproofing | 236 | 271 |
| Fuses | 60 | 62 |
| Gain control circuit, Agc amplifier: | | |
| Block diagram analysis | 184*a* | 193 |
| Schematic diagram analysis | 185*a* | 195 |
| General function: | | |
| Audio Frequency Amplifier AM–911/FG | 132 | 140 |
| Demultiplexer TD–98/FGR–3 | 131 | 140 |
| Multiplexer TD–97/FGT–2 | 130 | 140 |
| Telegraph receiver group | 129 | 139 |
| Telegraph transmitter group | 128 | 139 |
| General theory: | | |
| Auxiliary components | 140 | 146 |
| DIVERSITY ALIGNMENT PANEL | 140*c* | 146 |
| General | 135 | 142 |
| Power distribution circuits | 141 | 146 |
| RECEIVER METER PANEL | 140*b* | 146 |
| Receiving terminal: | | |
| 6–kc lines | 137 | 143 |
| 3–kc lines | 139 | 145 |
| TRANSMITTER METER PANEL | 140*a* | 146 |
| Transmitting terminal: | | |
| 6–kc lines | 136 | 143 |
| 3–kc lines | 138 | 145 |
| Ground connection | 51*b* | 45 |
| Impedance matching connections | 53 | 52 |
| Inductor and transformer tests | 250 | 282 |
| Initial adjustments and tests: | | |
| Combiner | 94 | 112 |
| Demultiplexer TD–98/FGR–3 | 91 | 111 |
| DIVERSITY ALIGNMENT PANEL | 87 | 109 |
| General | 82 | 106 |
| LEVEL CONTROL & PLATE SUPPLY | 90 | 110 |
| Multiplexer TD–97/FGT–2 | 91 | 111 |
| Receiver | 93 | 112 |
| RECEIVER METER PANEL | 86 | 109 |
| SUBGROUP DEMODULATOR | 92 | 111 |
| SUBGROUP MODULATOR | 89 | 110 |
| Transmitter | 88 | 109 |
| TRANSMITTER METER PANEL | 85 | 108 |

| | Paragraph | Page |
|---|---|---|
| Input carrier frequencies: | | |
| Combiner | 12*c* | 8 |
| Receiver | 11*d* | 8 |
| SUBGROUP DEMODULATOR | 10*c* | 7 |
| SUBGROUP MODULATOR | 8*c* | 6 |
| Input circuits, transmitter, schematic diagram analysis | 145 | 149 |
| Input network: | | |
| Tests | 293*c* | 357 |
| Theory | 178 | 187 |
| Installation: | | |
| Additional equipment | 59 | 60 |
| Cabinets | 47 | 37 |
| Planning | 39 | 24 |
| Intercabinet power wiring duct | 51*a*(1) | 43 |
| Intercabinet signal wiring duct | 52*a*(1) | 47 |
| Isolation, trouble. (*See* Trouble isolation.) | | |
| Jacks and controls: | | |
| Combiner | 190*f* | 212 |
| Receiver | 182*c* | 190 |
| SUBGROUP MODULATOR | 157*d* | 162 |
| Transmitter | 151 | 157 |
| Keyer Y1 or Y2: | | |
| Theory. (*See* Transmitter, schematic diagram analysis.) | | |
| Trouble isolation | 261 | 303 |
| Level control and attenuator tests | 249 | 281 |
| LEVEL CONTROL & PLATE SUPPLY: | | |
| Additional troubleshooting information | 281 | 342 |
| Block diagram analysis | 168 | 178 |
| Controls | 65 | 68 |
| Description | 28 | 16 |
| Operational test | 276 | 336 |
| Schematic diagram analysis | 169 | 179 |
| Technical characteristics | 9 | 7 |
| Theory, general | 167 | 178 |
| Trouble localization | 278 | 338 |
| Troubleshooting chart | 277 | 337 |
| LEVEL METER circuit: | | |
| RECEIVER METER PANEL: | | |
| Block diagram analysis | 227*a* | 260 |
| Schematic diagram analysis | 228*a* | 261 |
| TRANSMITTER METER PANEL: | | |
| Block diagram analysis | 225*a* | 255 |
| Schematic diagram analysis | 226*a* | 256 |
| Levels: | | |
| Audio Frequency Amplifier AM–911/FG: | | |
| Input | 110*d* | 127 |
| Output | 110*e* | 127 |
| Demultiplexer TD–98/FGR–3: | | |
| Input | 110*b* | 126 |
| Maximum permissible | 14*d* | 9 |
| Normal operating | 14*c* | 9 |
| Output | 110*c* | 126 |
| Facsimile operating | 43*d* | 34 |
| Facsimile operation with carrier telephone facilities | 44*b* | 34 |
| Levels—Continued | | |
| Multiplexer TD–97/FGT–2: | | |
| Input | 108*b* | 125 |
| Maximum permissible | 13*d* | 8 |
| Normal operating | 13*c* | 8 |
| Output | 108*c* | 125 |
| Radio receiver output | 109*b*, 110*a* | 126 |
| Radio transmitter input | 109*a* | 125 |
| Receiver input | 11*e* | 8 |
| SUBGROUP DEMODULATOR: | | |
| Input | 10*e* | 7 |
| Output | 10*g* | 7 |
| SUBGROUP MODULATOR: | | |
| Input | 8*e* | 6 |
| Output | 8*g* | 6 |
| Telegraph operating | 38*b* | 23 |
| Telegraph operation with carrier telephone facilities | 44*a*,*b* | 34 |
| Telephone transmission | 43*b* | 34 |
| Terminal equipment output | 108*a* | 124 |
| Transmitter output | 7*d* | 6 |
| Limited storage: | | |
| Disassembly | 349 | 426 |
| Repacking | 350 | 427 |
| Line amplifier: | | |
| Block diagram analysis | 170 | 180 |
| Schematic diagram analysis | 171 | 181 |
| Trouble isolation | 279 | 340 |
| Line impedance matching | 42 | 32 |
| Line-up check: | | |
| DELAY ADJUST METER | 103 | 120 |
| SUBGROUP DEMODULATOR | 102 | 119 |
| Line-up procedure: | | |
| Audio Frequency Amplifier AM–911/FG | 106 | 122 |
| Checks, routine | 112 | 129 |
| Combiner | 100 | 117 |
| Delay amplifier | 101 | 119 |
| Demultiplexer TD–98/FGR–3 | 105 | 121 |
| General | 95 | 112 |
| Multiplexer TD–97/FGT–2 | 104 | 121 |
| Radio circuit | 109 | 125 |
| Receivers | 99 | 115 |
| Receiving direction | 110 | 126 |
| System. (*See* System line-up procedures.) | | |
| Telegraph receiver group | 97 | 115 |
| Telegraph receiver group, preliminary | 98 | 115 |
| Telegraph transmitter group | 96 | 112 |
| Transmitting direction | 108 | 124 |
| Listening tests: | | |
| Receiving terminal | 257*b* | 289 |
| Transmitting terminal | 256*b* | 284 |
| Localization, trouble. (*See* Trouble localization.) | | |
| Loop battery: | | |
| General | 38*a*(5) | 23 |
| Options | 6*c* | 5 |
| LOOP BATTERY PANEL: | | |
| Access to parts | 245*d* | 79 |
| Controls | 80 | 101 |

| | Paragraph | Page |
|---|---|---|
| LOOP BATTERY PANEL—Continued | | |
| Operational test | 317 | 396 |
| Theory | 221 | 250 |
| Trouble localization | 319 | 398 |
| Troubleshooting chart | 318 | 397 |
| Loop battery supply: | | |
| Access to parts | 245*e* | 279 |
| Additional troubleshooting information | 323 | 402 |
| Operational test | 320 | 399 |
| Theory | 222 | 251 |
| Trouble localization | 322 | 401 |
| Troubleshooting chart | 321 | 399 |
| Loop battery voltage distribution: | | |
| General | 216*b* | 247 |
| Receiving terminal | 220 | 250 |
| System, trouble sectionalization | 253 | 283 |
| Transmitting terminal | 219 | 247 |
| LOOP CURRENT METER circuit: | | |
| RECEIVER METER PANEL: | | |
| Block diagram analysis | 227 | 259 |
| Schematic diagram analysis | 228 | 260 |
| TRANSMITTING METER PANEL: | | |
| Block diagram analysis | 225 | 255 |
| Schematic diagram analysis | 226 | 256 |
| Lubrication: | | |
| Attenuators | 234*a* | 270 |
| Blower motors | 235 | 271 |
| Drawer slides | 233 | 270 |
| Level adjust controls | 234*a* | 270 |
| Main power unit: | | |
| Access to parts | 245*g* | 280 |
| Additional troubleshooting information | 337 | 419 |
| Controls | 77 | 99 |
| Meter measurements: | | |
| Operating | 113 | 130 |
| Troubleshooting: | | |
| Receiving terminal | 257*c* | 290 |
| Transmitting terminal | 256*c* | 285 |
| Methods of destruction | 352 | 427 |
| Mod filter 1: | | |
| Tests | 274 | 330 |
| Theory | 160 | 168 |
| Mod filter 2: | | |
| Tests | 274 | 330 |
| Theory | 161 | 168 |
| Modulator: | | |
| SUBGROUP DEMODULATOR: | | |
| Theory | 178 | 187 |
| Trouble isolation | 292 | 355 |
| SUBGROUP MODULATOR: | | |
| Theory | 164 | 175 |
| Trouble isolation | 271 | 324 |
| Moistureproofing | 236 | 271 |
| Multiplexer TD–97/FGT–2: | | |
| Block diagram analysis | 195 | 217 |
| Controls | 70 | 82 |
| Description | 32 | 21 |
| General function | 130 | 140 |
| Installation planning | 39*b* | 25 |
| Multiplexer TD–97/FGT–2—Continued | | |
| Locations, optional | 48 | 39 |
| Technical characteristics | 13 | 8 |
| Number per AN/FGC–29 terminal: | | |
| Audio Frequency Amplifier AM–911/FG | 15*a* | 9 |
| Cabinets | 6*h* | 5 |
| Combiner | 12*a* | 8 |
| Demultiplexer TD–98/FGR–3 | 14*a* | 9 |
| LEVEL CONTROL & PLATE SUPPLY | 9*a* | 7 |
| Multiplexer TD–97/FGT–2 | 13*a* | 8 |
| Receiver | 11*a* | 8 |
| SUBGROUP DEMODULATOR | 10*a* | 7 |
| SUBGROUP MODULATOR | 8*a* | 6 |
| Transmitter | 7*a* | 6 |
| Tubes | 6*i* | 5 |
| Oiling air filters | 234*b* | 270 |
| Operating procedure: | | |
| General | 114 | 130 |
| Receiving vf circuits | 117 | 134 |
| Telegraph receiver group | 118 | 134 |
| Telegraph transmitter group | 115 | 131 |
| Transmitting vf circuits | 116 | 133 |
| Operation: | | |
| Emergency | 120 | 136 |
| Fading conditions, severe | 121 | 137 |
| Telegraph order wire circuits | 119 | 136 |
| Unusual conditions: | | |
| Arctic climates | 124 | 138 |
| Desert climates | 126 | 138 |
| General | 123 | 138 |
| Tropical climates | 125 | 138 |
| Operational test: | | |
| AC POWER SWITCHING PANEL | 310 | 389 |
| Combiner | 304 | 375 |
| DIVERSITY ALIGNMENT PANEL | 332 | 414 |
| LEVEL CONTROL & PLATE SUPPLY | 276 | 336 |
| LOOP BATTERY PANEL | 317 | 396 |
| Loop battery supply | 320 | 399 |
| Procedures, general | 239*b* | 272 |
| Receiver | 295 | 359 |
| RECEIVER METER PANEL | 328 | 408 |
| SUBGROUP DEMODULATOR | 288 | 350 |
| SUBGROUP MODULATOR | 267 | 315 |
| 3KC RECEIVE BAND TEST PANEL | 287 | 348 |
| 3KC SEND BAND TEST PANEL | 283 | 344 |
| Transformer Assembly TF–206/FG | 284 | 346 |
| Transmitter | 258 | 297 |
| TRANSMITTER METER PANEL | 324 | 402 |
| Voltage regulator | 313 | 392 |
| Optional Locations of Multiplexers TD–97/FGT–2, Demultiplexers TD–98/FGR–3, and Audio Frequency Amplifiers AM–911/FG | 48 | 39 |
| Order wire circuit, telegraph | 119 | 136 |

| | Paragraph | Page |
|---|---|---|
| Oscillator and buffer amplifier circuits, schematic diagram analysis | 148 | 154 |
| Oscillator circuit, 19.38–kc, converter, schematic diagram analysis | 159*a* | 165 |
| Oscillator circuit, 25.16–kc, carrier supply, schematic diagram analysis | 163*a* | 170 |
| Oscillator keying circuit, transmitter, schematic diagram analysis | 147 | 152 |
| Oscillator tuner Z1 or Z2: | | |
| Theory. (*See* Oscillator, keying circuit.) | | |
| Trouble isolation | 263 | 309 |
| Output carrier frequencies: | | |
| Receiver | 11*d* | 8 |
| SUBGROUP DEMODULATOR | 10*d* | 7 |
| SUBGROUP MODULATOR | 8*d* | 6 |
| Transmitter | 7*c* | 6 |
| Output circuits, transmitter, schematic diagram analysis | 149 | 156 |
| Painting | 237 | 271 |
| Parts: | | |
| Accessible to | 245 | 278 |
| Pluck-out, removal and test | 243 | 276 |
| Plate supply: | | |
| LEVEL CONTROL & PLATE SUPPLY: | | |
| Theory | 169*b* | 179 |
| Trouble isolation | 280 | 342 |
| Receiver: | | |
| Theory | 186 | 202 |
| Trouble isolation | 300 | 371 |
| SUBGROUP MODULATOR: | | |
| Theory | 166 | 178 |
| Trouble isolation | 273 | 330 |
| SUBGROUP DEMODULATOR: | | |
| Theory | 178 | 187 |
| Trouble isolation | 292 | 355 |
| Power circuit, DIVERSITY ALIGNMENT PANEL: | | |
| Block diagram analysis | 229 | 267 |
| Schematic diagram analysis | 230 | 268 |
| Power distribution circuits, general theory: | | |
| Receiving terminal | 141*b* | 147 |
| Transmitting terminal | 141*a* | 146 |
| Power requirements: | | |
| Audio Frequency Amplifier AM–911/FG | 15 | 9 |
| Combiner | 12 | 8 |
| Demultiplexer TD–98/FGR–3 | 14 | 9 |
| LEVEL CONTROL & PLATE SUPPLY | 9 | 7 |
| Multiplexer TD–97/FGT–2 | 13 | 8 |
| Receiver | 11 | 8 |
| SUBGROUP DEMODULATOR | 10 | 7 |
| SUBGROUP MODULATOR | 8 | 6 |
| Telegraph Terminal AN/FGC–29 | 6 | 5 |
| Transmitter | 7 | 6 |
| Power supply circuits, transmitter, schematic diagram analysis | 150 | 156 |
| Preliminary starting procedure | 83 | 106 |
| Preventive maintenance services: | | |
| Definition | 231 | 270 |
| Techniques, general | 232 | 270 |
| Purpose and use | 3 | 1 |
| Ratio-squaring diversity combining | 134*c* | 142 |
| Receiver: | | |
| Access to parts | 245*a* | 278 |
| Additional troubleshooting information | 303 | 373 |
| Block diagram analysis | 181 | 188 |
| Controls | 67 | 74 |
| Description | 30 | 20 |
| Operational test | 295 | 359 |
| Schematic diagram analysis | 182 | 188 |
| Technical characteristics | 11 | 8 |
| Trouble localization | 297 | 362 |
| Troubleshooting chart | 296 | 360 |
| Receiver filter FL1 or FL2, theory | 187 | 202 |
| RECEIVER METER PANEL: | | |
| Access to parts | 245*b* | 279 |
| Additional troubleshooting information | 331 | 413 |
| Block diagram analysis | 227 | 259 |
| Controls | 75 | 93 |
| Operational test | 328 | 408 |
| Schematic diagram analysis | 228 | 260 |
| Theory, general | 140*b* | 146 |
| Trouble localization | 330 | 412 |
| Troubleshooting chart | 329 | 410 |
| Receiving terminal: | | |
| Ac power distribution | 212 | 240 |
| Cording connections: | | |
| 6-kc operation | 49*a*(2) | 41 |
| 3-kc operation | 49*b*(2) | 41 |
| External signal connections: | | |
| Input | 52*b*(1) | 48 |
| Output connections | 52*b*(2) | 48 |
| Frequency diversity routing connections: | | |
| 6-kc operation | 57*c* | 57 |
| 3-kc operation | 57*b* | 57 |
| Interconnections: | | |
| Power | 50*b*(2) | 42 |
| Signal | 50*b*(1) | 41 |
| 6-kc line facilities, use | 40*c* | 27 |
| Space diversity routing connections: | | |
| 3-kc operation | 55*b* | 54 |
| 6-kc operation | 55*c* | 54 |
| Theory: | | |
| General | 203 | 227 |
| Remote control circuits | 209 | 236 |
| 3-kc line facilities | 41*c* | 27 |
| RECTIFIER A. (*See* Loop battery supply.) | | |
| RECTIFIER B. (*See* Loop battery supply.) | | |
| RELAY PANEL: | | |
| Additional troubleshooting information | 342 | 423 |
| Theory | 223 | 254 |

| | Paragraph | Page |
|---|---|---|
| Relay rack cabinet | 36*a* | 22 |
| Remote control circuits: | | |
| Sectionalization of trouble | 255 | 283 |
| Theory: | | |
| General | 207 | 236 |
| Receiving terminal | 209 | 236 |
| Transmitting terminal | 208 | 236 |
| Remote diversity switching connections: | | |
| Receiving terminal | 52*c* | 49 |
| Transmitting terminal | 52*b* | 48 |
| Removal and test of pluck-out parts | 243 | 276 |
| Repacking for shipment or limited storage | 350 | 427 |
| Resistance measurements | | |
| Combiner | 309*a* | 385 |
| DIVERSITY ALIGNMENT PANEL | 335*a* | 418 |
| Instructions, general | 247 | 280 |
| LEVEL CONTROL & PLATE SUPPLY | 281 | 342 |
| Loop battery supply | 323 | 402 |
| Main power unit | 337 | 419 |
| Receiver | 303 | 373 |
| RECEIVER METER PANEL | 331 | 413 |
| RELAY PANEL | 342 | 423 |
| Step-up power transformer assembly | 338 | 419 |
| SUBGROUP DEMODULATOR | 294 | 358 |
| SUBGROUP MODULATOR | 275 | 334 |
| Transmitter | 266 | 313 |
| TRANSMITTER METER PANEL | 327 | 407 |
| Voltage regulator | 316 | 395 |
| Resistor tests | 248 | 280 |
| Resonance test: | | |
| Carrier supply | 272*b* | 326 |
| Converter | 270*c* | 321 |
| Roof opening use: | | |
| Power connections | 51*a*(2) | 44 |
| Signal connections | 52*a*(2) | 46 |
| Routine line-up checks | 112 | 129 |
| Running spares | 35 | 21 |
| Rustproofing and painting | 237 | 271 |
| Schematic diagram analysis: | | |
| Age amplifier | 185 | 195 |
| Band amplifier | 176 | 186 |
| Carrier supply, SUBGROUP MODULATOR | 163 | 170 |
| Combiner | 190 | 205 |
| Converter | 159 | 165 |
| DELAY ADJUST METER circuit | 228*c* | 261 |
| DIVERSITY ALIGNMENT PANEL | 230 | 268 |
| Dotter circuit | 226*c* | 258 |
| Frequency divider circuit, 19.38–kc to 9.69–kc, converter | 159*b* | 165 |
| Frequency divider circuit, 25.16–kc to 6.29–kc, carrier supply | 163 | 170 |
| Input circuits, transmitter | 145 | 149 |
| Line amplifier | 171 | 181 |
| LEVEL CONTROL & PLATE SUPPLY | 169 | 179 |
| LEVEL METER circuit, RECEIVER METER PANEL | 228*a* | 261 |
| Schematic diagram analysis—Continued | | |
| LEVEL METER circuit, TRANSMITTER METER PANEL | 226*a* | 256 |
| LOOP CURRENT METER circuit, RECEIVER METER PANEL | 228*b* | 261 |
| LOOP CURRENT METER circuit, TRANSMITTER METER PANEL | 226*b* | 257 |
| Oscillator and buffer amplifier circuits | 148 | 154 |
| Oscillator keying circuit, transmitter | 147 | 152 |
| Oscillator circuit, 19.38–kc, converter | 159*a* | 165 |
| Oscillator circuit, 25.16–kc, carrier supply | 163*a* | 170 |
| Output circuits, transmitter | 149 | 156 |
| Power supply circuits, transmitter | 150 | 156 |
| Receiver | 182 | 188 |
| RECEIVER METER PANEL | 228 | 260 |
| Receiving terminal, 6–kc lines | 204 | 228 |
| Receiving terminal, 3–kc lines | 205 | 233 |
| Signal modulator, Converter | 159*d* | 167 |
| Square wave amplifier circuit, carrier supply | 163*c* | 173 |
| Square wave amplifier circuit, converter | 159*c* | 166 |
| SUBGROUP DEMODULATOR | 174 | 184 |
| SUBGROUP MODULATOR | 157 | 160 |
| Switching circuits, transmitter | 146 | 149 |
| Transmitter | 144 | 149 |
| TRANSMITTER METER PANEL | 226 | 256 |
| Transmitting terminal, 6–kc lines | 199 | 222 |
| Transmitting terminal, 3–kc lines | 200 | 224 |
| Voltage regulator | 215 | 243 |
| Scope of manual | 1 | 1 |
| Sectionalization, trouble. (*See* Trouble sectionalization.) | | |
| Selective fading, theory | 133*b* | 141 |
| Service upon receipt of used or reconditioned equipment | 61 | 63 |
| Signal modulator, converter, schematic diagram analysis | 159*d* | 167 |
| Simplex connections: | | |
| Receiving terminal | 52*c* | 49 |
| Transmitting terminal | 52*b* | 48 |
| Single-sideband radio operation | 133 | 141 |
| Siting | 45 | 35 |
| 6–kc line facilities: | | |
| Routing connections, | | |
| Receiving terminal, | | |
| Space diversity | 55*c* | 54 |
| Frequency diversity | 57*c* | 57 |
| Transmitting terminal, | | |
| Space diversity | 54*c* | 53 |
| Frequency diversity | 56*c* | 55 |
| Use of equipment | 40 | 25 |
| Size of terminal | 6*f* | 5 |
| Sky-wave transmission, theory | 133*a* | 141 |
| Space diversity: | | |
| 6–kc line facilities | 41*c*(2) | 32 |
| Telegraph service | 38*a*(2) | 23 |
| Theory | 134*b* | 141 |
| 3–kc line facilities | 40*c*(1) | 27 |

| | Paragraph | Page |
|---|---|---|
| Space diversity routing connections: | | |
| Receiving terminal | 55 | 54 |
| Transmitting terminal | 54 | 53 |
| Specific telegraph level, definition | 44 | 34 |
| Square wave amplifier circuit, schematic diagram analysis: | | |
| Carrier supply | 163*c* | 173 |
| Converter | 159*c* | 166 |
| Starting procedure | 84 | 107 |
| Step-up power transformer, troubleshooting | 338 | 419 |
| Stopping procedure | 122 | 138 |
| SUBGROUP DEMODULATOR: | | |
| Additional troubleshooting information | 294 | 358 |
| Block diagram analysis | 173 | 182 |
| Controls | 66 | 69 |
| Description | 29 | 20 |
| Operational test | 288 | 350 |
| Schematic diagram analysis | 174 | 184 |
| Technical characteristics | 10 | 7 |
| Trouble localization | 290 | 354 |
| Troubleshooting chart | 289 | 352 |
| SUBGROUP MODULATOR: | | |
| Additional troubleshooting information | 275 | 334 |
| Block diagram analysis | 156 | 160 |
| Controls | 64 | 67 |
| Description | 27 | 16 |
| Operational test | 267 | 315 |
| Schematic diagram analysis | 157 | 160 |
| Technical characteristics | 8 | 6 |
| Trouble localization | 269 | 317 |
| Troubleshooting chart | 268 | 316 |
| Switching circuits, transmitter, schematic diagram analysis | 146 | 149 |
| System application | 5 | 2 |
| System line-up procedure: | | |
| Meter measurements | 113 | 130 |
| Radio circuit | 109 | 125 |
| Receiving direction | 110 | 126 |
| Transmitting direction | 108 | 124 |
| System planning: | | |
| Carrier telephone facilities | 44 | 34 |
| General | 37 | 23 |
| Installation planning | 39 | 24 |
| Line facilities, 6-kc | 40 | 25 |
| Line facilities, 3-kc | 41 | 27 |
| Line impedance matching | 42 | 32 |
| Telegraph service | 38 | 23 |
| Table of components | 17 | 10 |
| Technical characteristics: | | |
| Audio Frequency Amplifier AM-911/FG | 15 | 9 |
| Combiner | 12 | 8 |
| Demultiplexer TD-98/FGR-3 | 14 | 9 |
| LEVEL CONTROL & PLATE SUPPLY | 9 | 7 |
| Multiplexer TD-97/FGT-2 | 13 | 8 |
| Receiver | 11 | 8 |
| SUBGROUP DEMODULATOR | 10 | 7 |
| SUBGROUP MODULATOR | 8 | 6 |
| Technical characteristics—Continued | | |
| Telegraph Terminal AN/FGC-29 | 6 | 5 |
| Transmitter | 7 | 6 |
| Telegraph operating levels | 38*b* | 23 |
| Telegraph operation with carrier telephone facilities | 44*a* | 34 |
| Telegraph order wire circuits, operation | 119 | 136 |
| Telegraph receiver group: | | |
| General function | 129 | 139 |
| General theory: | | |
| 6-kc lines | 137*b* | 143 |
| 3-kc lines | 139*b* | 145 |
| Telegraph service | 38 | 23 |
| Telegraph Terminal AN/FGR-3. (*See* Receiving terminal.) | | |
| Telegraph Terminal AN/FGT-2. (*See* Transmitting terminal.) | | |
| Telegraph transmitter group: | | |
| General function | 128 | 139 |
| General theory: | | |
| 6-kc lines | 136*a* | 143 |
| 3-kc lines | 138*a* | 145 |
| Telephone operation over carrier telephone facilities | 44 | 34 |
| Telephone service | 43 | 34 |
| Terminating measurements. (*See* Meter measurements.) | | |
| 3-kc line facilities: | | |
| Routing connections: | | |
| Receiving terminal: | | |
| Frequency diversity | 57*b* | 57 |
| Space diversity | 55*b* | 54 |
| Transmitting terminal: | | |
| Frequency diversity | 56*b* | 55 |
| Space diversity | 54*b* | 53 |
| Use of equipment | 41 | 27 |
| 3KC RECEIVE BAND TEST PANEL: | | |
| Controls | 73 | 92 |
| Operational test | 287 | 348 |
| Theory | 206 | 234 |
| Troubleshooting procedure | 286 | 348 |
| 3KC SEND BAND TEST PANEL: | | |
| Controls | 69 | 79 |
| Operational test | 283 | 344 |
| Theory | 202 | 225 |
| Troubleshooting procedure | 282 | 343 |
| Transformer Assembly TF-206/FG: | | |
| Operational test | 284 | 346 |
| Theory | 201 | 225 |
| Transformer reactor assembly, theory | 191 | 212 |
| Transmission: | | |
| Levels. (*See* Levels.) | | |
| Medium | 6*k* | 5 |
| Single-sideband | 133*c* | 141 |
| Sky wave | 133*a* | 141 |
| Transmission circuits: | | |
| Audio Frequency Amplifier AM-911/FG | 15*b* | 9 |
| Combiner | 12*b* | 8 |
| Demultiplexer TD-98/FGR-3 | 14*b* | 9 |
| LEVEL CONTROL & PLATE SUPPLY | 9*b* | 7 |

| | Paragraph | Page |
|---|---|---|
| Transmission circuits—Continued | | |
| Multiplexer TD–97/FGT–2 | 13*b* | 8 |
| Receiver | 11*b* | 8 |
| SUBGROUP DEMODULATOR | 10*b* | 7 |
| SUBGROUP MODULATOR | 8*b* | 6 |
| Transmitter | 7*b* | 6 |
| Transmitter: | | |
| Access to parts | 245*a* | 278 |
| Additional troubleshooting information | 266 | 313 |
| Bias supply, theory | 152 | 157 |
| Block diagram analysis | 143 | 148 |
| Controls | 63 | 64 |
| Description | 26 | 16 |
| Filter tests | 265 | 312 |
| Input circuits, schematic diagram analysis | 145 | 149 |
| Jacks and controls, theory | 151 | 157 |
| Operational test | 258 | 297 |
| Oscillator and buffer amplifier circuits, schematic diagram analysis | 148 | 154 |
| Oscillator keying circuit, schematic diagram analysis | 147 | 152 |
| Output circuits, schematic diagram analysis | 149 | 156 |
| Power supply circuits, schematic diagram analysis | 150 | 156 |
| Schematic diagram analysis | 144 | 149 |
| Switching circuits, schematic diagram analysis | 146 | 149 |
| Technical characteristics | 7 | 6 |
| Theory, general | 142 | 147 |
| Transmitter filter, theory | 154 | 158 |
| Trouble localization | 260 | 302 |
| Troubleshooting chart | 259 | 299 |
| Tuned network, theory | 153 | 157 |
| Transmitter filter, theory | 154 | 158 |
| TRANSMITTER METER PANEL: | | |
| Access to parts | 245*b* | 279 |
| Additional troubleshooting information | 327 | 407 |
| Block diagram analysis | 225 | 255 |
| Controls | 74 | 92 |
| Operational test | 324 | 402 |
| Schematic diagram analysis | 226 | 256 |
| Theory, general | 140*a* | 146 |
| Trouble localization | 326 | 406 |
| Troubleshooting chart | 325 | 403 |
| Transmitting terminal: | | |
| Ac power distribution | 211 | 239 |
| Cording connections: | | |
| 6–kc operation | 49*a*(1) | 41 |
| 3–kc operation | 49*b*(1) | 41 |
| External signal connections: | | |
| Input | 52*b*(4) | 49 |
| Output | 52*b*(2) | 48 |
| Frequency diversity routing connections: | | |
| 3–kc line facilities | 56*b* | 55 |
| 6–kc line facilities | 56*c* | 55 |
| Transmitting terminal—Continued | | |
| Interconnections: | | |
| Power | 50*a*(2) | 41 |
| Signal | 50*a*(1) | 41 |
| Schematic diagram analysis: | | |
| 6–kc lines | 199 | 222 |
| 3–kc lines | 200 | 224 |
| 6–kc line facilities, use | 40*b* | 25 |
| Space diversity routing connections: | | |
| 3–kc facilities | 54*b* | 53 |
| 6–kc facilities | 54*c* | 53 |
| Theory: | | |
| General | 198 | 222 |
| Remote control circuits | 208 | 236 |
| 3–kc line facilities, use | 41*b* | 27 |
| Tropical climates, operation | 125 | 138 |
| Trouble isolation: | | |
| Adder | 307 | 382 |
| Agc amplifier | 299 | 365 |
| Carrier supply: | | |
| SUBGROUP DEMODULATOR | 292 | 355 |
| SUBGROUP MODULATOR | 272 | 325 |
| Converter: | | |
| SUBGROUP DEMODULATOR | 292 | 355 |
| SUBGROUP MODULATOR | 270 | 321 |
| Band amplifier | 291 | 355 |
| Bias supply | 262 | 308 |
| Delay amplifier | 298 | 364 |
| Keyer | 261 | 303 |
| Line amplifier | 279 | 340 |
| Modulator: | | |
| SUBGROUP DEMODULATOR | 292 | 355 |
| SUBGROUP MODULATOR | 271 | 324 |
| Oscillator tuner | 263 | 309 |
| Plate supply: | | |
| LEVEL CONTROL & PLATE SUPPLY | 280 | 342 |
| Receiver | 300 | 371 |
| SUBGROUP DEMODULATOR | 292 | 355 |
| SUBGROUP MODULATOR | 273 | 330 |
| Trouble localization: | | |
| AC POWER SWITCHING PANEL | 312 | 391 |
| Combiner | 306 | 315 |
| DIVERSITY ALIGNMENT PANEL | 334 | 416 |
| LEVEL CONTROL & PLATE SUPPLY | 278 | 338 |
| LOOP BATTERY PANEL | 319 | 398 |
| Loop battery supply | 322 | 401 |
| Receiver | 297 | 362 |
| RECEIVER METER PANEL | 330 | 412 |
| SUBGROUP DEMODULATOR | 290 | 354 |
| SUBGROUP MODULATOR | 269 | 317 |
| Transmitter | 260 | 302 |
| TRANSMITTING METER PANEL | 326 | 403 |
| Voltage regulator | 315 | 394 |

| | Paragraph | Page |
|---|---|---|
| Trouble sectionalization: | | |
| Ac power distribution system | 252 | 282 |
| AN/FGC–29 terminal | 251 | 282 |
| B-plus voltage distribution system | 254 | 283 |
| Loop battery voltage distribution system | 253 | 283 |
| Procedures, general | 239*a* | 272 |
| Remote control system | 255 | 283 |
| Signal path system, receiving terminal | 257 | 289 |
| Signal path system, transmitting terminal | 256 | 284 |
| Troubleshooting: | | |
| Access to parts, instructions | 245 | 278 |
| Attenuator tests | 249*b* | 281 |
| Charts. (*See* Troubleshooting chart.) | | |
| Data | 240 | 272 |
| General | 238 | 271 |
| Inductor tests | 250 | 282 |
| Level control tests | 249*a* | 281 |
| Precautions, general | 244 | 278 |
| Procedures, general | 239 | 271 |
| Removal and test of pluck-out parts | 243 | 276 |
| Resistance measurements | 247 | 280 |
| Resistor tests | 248 | 280 |
| Transformer tests | 250 | 282 |
| Tools and test equipment required | 241 | 276 |
| Visual inspection | 242 | 276 |
| Voltage measurements | 246 | 280 |
| Troubleshooting chart: | | |
| AC POWER SWITCHING PANEL | 311 | 390 |
| Combiner | 305 | 376 |
| DIVERSITY ALIGNMENT PANEL | 333 | 414 |
| LEVEL CONTROL & PLATE SUPPLY | 277 | 337 |
| LOOP BATTERY PANEL | 318 | 397 |
| Loop battery supply | 321 | 399 |
| Receiver | 296 | 360 |
| RECEIVER METER PANEL | 329 | 410 |
| SUBGROUP DEMODULATOR | 289 | 352 |
| SUBGROUP MODULATOR | 268 | 316 |
| Transmitter | 259 | 299 |
| TRANSMITTER METER PANEL | 325 | 403 |
| Voltage regulator | 314 | 392 |
| Trunk connections: | | |
| Receiving terminal | 52*c* | 49 |
| Transmitting terminal | 52*b* | 48 |
| Tuned network, transmitter: | | |
| Tests | 264 | 311 |
| Theory | 153 | 157 |
| Typical installation | 39*a* | 24 |
| Uncrating, unpacking, and checking new equipment | 46 | 35 |
| Used or reconditioned equipment, service upon receipt | 61 | 63 |
| Visual inspection | 242 | 276 |
| Voltage measurements: | | |
| Combiner | 309*b* | 337 |
| DIVERSITY ALIGNMENT PANEL | 335*b* | 419 |
| Instructions, general | 245 | 278 |
| LEVEL CONTROL & PLATE SUPPLY | 281*b* | 343 |
| Loop battery supply | 323*b* | 402 |
| Receiver | 303*b* | 374 |
| RECEIVER METER PANEL | 331*b* | 414 |
| SUBGROUP DEMODULATOR | 294*b* | 358 |
| SUBGROUP MODULATOR | 275*b* | 335 |
| Transmitter | 266*b* | 314 |
| TRANSMITTER METER PANEL | 327*b* | 408 |
| Voltage regulator | 316*b* | 396 |
| Voltage regulator: | | |
| Access to parts | 245*c* | 279 |
| Additional troubleshooting information | 316 | 395 |
| Block diagram analysis | 214 | 242 |
| Controls | 79 | 99 |
| Operational test | 313 | 392 |
| Schematic diagram analysis | 215 | 243 |
| Trouble localization | 315 | 394 |
| Troubleshooting chart | 314 | 392 |
| Volume Indicator ID–220A/FRT or Volume Indicator ID–220B/FRT | 36*b* | 22 |
| Weight of terminal | 6*g* | 5 |

By Order of *Wilber M. Brucker*, Secretary of the Army:

MAXWELL D. TAYLOR,
*General, United States Army,*
*Chief of Staff.*

Official:

JOHN A. KLEIN,
*Major General, United States Army,*
*The Adjutant General.*

Distribution:

*Active Army:*

CNGB (1)
ASA (3)
Tec Svc, DA (1) except CSIGO (30)
Tec Svc Bd (1)
Hq CONARC (5)
CONARC Bd (Incl ea Test Sec) (1)
Army AA Comd (2)
OS Maj Comd (5)
OS Base Comd (5)
Log Comd (5)
MDW (1)
Armies (5)
Corps (2)
Ft & Cp (2)
Sp Wpn Comd (2)
Army Cml Cen (4)
Gen & Br Svc Sch (5) except Sig Sch (25)
Gen Depots (2) except Atlanta Gen Depot (None)
Sig Sec, Gen Depots (10)
Sig Depots (17)
US Army Tng Cen (2)
POE (OS) (2)
Trans Terminal Comd (2)
Army Terminals (2)
OS Sup Agencies (2)
Army Elct PG (1)
Sig Fld Maint Shops (3)
Sig Lab (5)
ACS (3)
Mil Dist (1)
Unit organized under following TOE's:
11–7C, Sig Co, Inf Div (2)
11–16C, Hq & Hq Co, Sig Bn, Corps or Abn Corps (2)
11–57C, Armd Sig Co (2)
11–127R, Sig Rep Co (2)
11–128R, Sig Depot Co (2)
11–500R (AA–AE), Sig Svc Org (2)
11–557C, Abn Sig Co (2)
11–587R, Sig Base Maint Co (2)
11–592R, Hq & Hq Co, Sig Base Depot (2)
11–597R, Sig Base Depot Co (2)

*NG:* State AG (6); units—same as Active Army except allowance is one copy to each unit.
*USAR:* None.
For explanation of abbreviations used, see SR 320–50–1.

U. S. GOVERNMENT PRINTING OFFICE: 1956 O—395139